



~~NA. supra 8.~~

NA. 3.

Dr. Haighton was Obstetric Physician
to Guy's Hospital: in which office he was succeeded
by his nephew, Dr. Blundell, who died in 188-
very rich at about 90 years of age.

(1790-1877)
D.N.B.

1755-1823 Pupil of John Hunter. Lectured in Physiology at the School
of the General Hospital. For his physiological experiments which were cer-
tainly ruthless & numerous he was called by his opponents "The Merciless
Doctor" (see Pursuits of Literature p. 419) List of his papers in D.N.B.
Evidently an able man & capable physiologist.

HAIGHTON (JOHN) 1755-1823.

7570. In English, on paper (watermarked 1811):
written in 1815: 9 $\frac{1}{2}$ x 7 $\frac{3}{4}$ in., ii + 266
pages.

'Lectures on Physiology delivered in the
Theatre at Guy's Hospital by John Haigh-
ton, M.D.', '1815' (added later); MS. com-
pleted at Ardwick, 11 Mar., 1815 (see p. 257).

Owned by P. H. Pye-Smith, 1879, who has
written biographical notes inside the cover.

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physiological experiments, which were certainly
ruthless and numerous, he was called by his
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Mathias, 'Pursuits of Literature', 12th ed., 1803,
pp. 419-20). A list of his papers is in the D. N. B.
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[W. O.]

7570

PA Pye-Smith. Lectures on Physiology
in Guy's Hospital 1879.

Lectures on Physiology

delivered in the Theatre

at Guy's Hospital

by

John Houghton, M.D.

1815

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ii (cont.)

Erratum.

Read page 203 at 213, and vice versa 213 at 203.

Lecture 1st

At the commencement of a course of Lectures it is usual to give a general view of the plan that will be adopted & the order that will be taken in considering the subject propounded. To interest likewise more in the subject it is common to make some observation tending to display the utility, as well as to render it more intelligible. It is hoped much need not be said to convince you of the utility of Physiology & to explain their functions. The one investigates the structure, the other the operations of the Machine. The human body contains a number of different organs; to explain their healthy operations or functions is the business of the Physiologist. The advantages of Physiology are very apparent even in the first stages, for by knowing the natural functions of the different organs, we can no doubt more easily describe their unhealthy ones, & thus be enabled to moderate their inordinate actions & to assist them when weak or disabled. Hence in all ages great men have applied themselves to this study. Amongst the latest of these is Baron Haller, & he stands very high; the able Spallanzini & Fontana have likewise made great improvements. Besides the improvements which Physiology has derived from the exertions of individuals, it has been greatly encouraged & promoted by societies both here & abroad. The humane Society has proposed suspended Respiration as a subject for discussion, & this led to a more minute investigation of the economy of the Lungs, as being the organs chiefly concerned in that case. Digestion is no longer that intricate subject it was supposed to be by the Ancients; it is now however to be performed on Chemical principles, by a

fluid called the Gastric juice, which is secreted by arteries of the Stomach. We can also speak with equal certainty on the functions of the Absorbent system. By our great Harvey the circulation of the blood was clearly demonstrated. Theory of Optics has thrown great light upon the Mechanism of the Eye; & our knowledge of the Theory of sounds, has greatly assisted our acquaintance with the knowledge of the Ear. We then have gained a great deal, but although much has already been done, much still remains for the enquiry of future Physiologists. The economy of the Brain & nerves has been clearly ascertained; Muscular action is not accounted for & sanguification not clearly explained. The Theory of conception is yet involved in much obscurity. And it remains also to discover the use of the Thyroid Gland, Spleen, &c. To ascertain the use of the Gallen I have made many experiments; which will be related in these Lectures, together with the Theory deduced from their results. Many have depreciated the knowledge of Physiology as being merely Hypothetical and therefore of no real use, but such as do this, do it for an excuse for their idleness, or to bring others down on a level with their own contracted understandings. It has been said that the cure of diseases for the most part should be left to nature; & that the Physician should act merely as the Servant; but even in this limited view of the Physicians business it is necessary to know when the powers of nature are sufficient to effect a cure, that he may administer the proper assistance. He should be acquainted with the effects of certain causes acting on the System, & the progress & the changes that may be produced on them by certain remedies. Persons of respectable character as Physicians, have

been led to form a wrong prognosis, from not understanding the real cause of
 a complaint, & have gone on giving their whole attention to the symptoms
 & neglected the original disease; for instance, Anasarca is sometimes only
 symptomatic affection depending on some other case or disease. In
 this case it will disappear as soon as the original disease is removed. A
 respectable Physician attended a Gentleman with Pneumony and
 Dyspnea under which he laboured sometime without experiencing any
 permanent relief, Anasarca soon after succeeded; when the
 Practitioner instead of attending to the former symptoms, indiscri-
 minately treated the disease with Hydragogues, & Diuretics. Nature
 however triumphed over his practice & removed the Pneumony leaving
 the Anasarca, more as a matter of inconvenience than disease, this was
 soon relieved by punctures & the Patient cured. Here then was seen the
 incompetent knowledge of the Practitioner. A Physician fitted for his
 profession would certainly have considered the Pneumony as the
 original & primary disease, & attended to it; the Anasarca was merely Sym-
 ptomatic arising from a difficult & interrupted transmission in conse-
 quence of impeded respiration. The object of this course of Lectures
 is to explain the natural actions of the human body. Whenever we
 digress it is with a view to illustrate these. The human Body contains a
 number of organs, each of which are so connected & dependent on others that
 it is difficult to determine where to begin; we will endeavour to begin
 with the more simple, & proceed gradually to the more complex, but
 even in the simple organs some knowledge must be taken for granted

Nature points out to us which way we ought to proceed. To begin ~~with~~
 with that part of the organization of Animals which is the most common
 & found in those of the simplest organic structures. Man of all Animals
 is the most complex, & from him there is a regular gradation to the
 most simple. Have these any organ which is common to all Animals;
 every Animal has a Stomach or some cavity for receiving food, &
 converting it into Nourishment. This organ then is certainly the most
 proper to begin with, & when we come to speak of the ^{Animal Machine} coincidence
 between the Animal, Vegetable, & Mineral Kingdom, & point out
 the distinguishing marks of each. We then proceed to consider the
 principle of life; this is a subject very difficult to understand. There
 is a difference between life & the action of life. It will be next in
 order to take a view of Man & other Animals with respect to their food,
 before we consider the organ of digesting that food. Animals have
 different preferences for different kinds of food, & that not from caprice
 or whim, but from a difference of Structure in their digesting or
 masticating organs. Mastication then will be considered in
 many Animals as far as it tends to illustrate that of the human. This
 leads us to the consideration of Deglutition & Digestion. Digestion
 is that change produced on the food while in the Stomach; &
 performed by a liquor called gastric juice; hence we are led
 to consider the Stomach & its office both as the organ of secretion &
 a muscular organ, for by this the food is propelled into the Intestines.
 It will be the first that comes under our consideration. But before that it will be necessary

The muscularity of the Stomach assists also in vomiting. The Stomach is very likely to be affected, & that from causes seated in some distant part, thus pain in the head often produces sickness in the Stomach, & Vice Versa; The Stomach must then be considered an organ of Sympathy. After the food has been digested it has to pass through the Alimentary canal, which leads us to speak of the Muscular power of that organ. When the food has passed into the Intestines it has to undergo a second change, before it is fitted for the purpose of nourishment; this is called the process of Chylification & the manner in which nature performs this, will be considered. When the Chyle is completely formed it is taken up in the Mass of blood, & this is affected by Absorbent Vessels or Lactals, which arise from the intestines by open Mouths. But the food that we take in contains very different portions of the Nutrient principle, it must therefore follow that nature has some resource for ridding herself of the parts that are not nutritive. This leads us to speak of the Peristaltic Motion of the Intestines, & other means to get rid of the feculent matter. We have said that when the formation of the Chyle is completed, it is carried into the blood, hence we are led to speak of the blood. It is of that fluid that the solids are composed, which supplies the waste & exhaustion which is continually going on in the System, but it cannot do this while in a state of rest, it must be sent to every part of the body to convey nourishment; here then we take a view of the circulation of the blood, & shall speak also of the cause which retard or accelerate it. The heart has been the principal organ performing that office & will

form a subject for consideration; but the blood after circulating a short time becomes unfit for the purposes of life, & requires a change, which change is affected by the lungs, & hence we have of the functions of the lungs. To prove this we have only to open the Chest of a living Animal & we shall see the blood coming from different parts of the body nearly black, while that which is coming from the lungs is of a bright florid red. This change is produced by the air taken into the lungs & the properties of the Air as far as they respect the change produced in the blood, is also the effects of suspended Respiration. Some remarks will be made here on Animal heat, & reference to Dr. Crawford's Experiments some of which appear highly probable. The blood is of two kinds Arterial & Venous; of these therefore we shall next speak at large. From the blood a number of fluids are secreted, not mechanically, but the blood seems to undergo a new mode of existence. This leads us to speak of the various secreting fluids, & the Glands which secrete them. We shall then proceed to the mind giving voluntary motion; the Brain & the Nerves as being the means of conveying this influence to the parts intended to be moved; we shall likewise consider how far it is connected in the effects of Sympathy & shall speak of the process of union between divided nerves & of what nature that union is. We come next to speak of the moving powers of the body & the origin of the Muscles Motion. After this we shall consider some changes taken place in the System, as those of Puberty & the change peculiar to Women, called Menstruation, & the effects of its interruption. Hence we consider the organs of each Sex, which are employed

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in the propagation & continuation of the Species, called the organs of generation. The Phenomena which occur during the act of generation & conception will then of course come under our immediate Notice.

Lecture 2nd Animal, Vegetable & Mineral Kingdoms.

If we take a view of Nature we find a wonderful diversity in its different parts, which often renders it difficult to determine to what Genus each Species belongs. The more readily to do this, Philosophers have thought fit to arrange the whole under three grand divisions, & under each of which will every part of nature be comprehended. The divisions are into the Animal, Vegetable & Mineral Kingdoms. In general every substance may be referred to one of these, but there are some of which can hardly be distinguished, so nice are the gradations & shades between them. The mineral is more distinct from the Vegetable, than the latter is from the Animal Kingdom, still there are many points in which they agree for the Mineral to bestow, very much resembles a piece of wood, though it will not burn. Animals & Vegetables have many points of coincidence & in which they both differ from Minerals. They have an internal Organization or peculiar arrangements of parts, which is not in the latter. Thus both of them have Vessels distributed through

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Their substance, as appears from their capability of being injected,
& which is best done after a few days when all their Vessels are
nearly empty. The vessels of plants do not appear to have much
communication with each other. The Onion is one of the easiest
to inject, & the way of doing it is to make an opening into the bul-
bous part, & then to introduce the quicksilver, which being a little
pressed will pass into the Vessels of the plant & a fine injection may be
sent into the Vessels by a Syringe. As Animals & Vegetables have
Vessels, so they have also fluids passing through them for their
nourishment, which does not appear to be the case with Minerals.
By means of this circulating fluid, they have within them
the power of growth. It is true Minerals increase in bulk,
but this is affected by an external deposit, or an aggregation of
particles. * Animals secrete, that is, have a power of forming fluids,
different to the one passing through them. The same takes
place in Vegetables, they have particular secretions, as their
Milk, Oil, Gum, & even Sugar is of this kind. Almost every
plant has some secretion, as the Poppy which affords a Secretion
of Milk. Some have more than one as the Orange & Lemon
which secrete an Acid & essential Oil. Again with regard to
Respiration these Kingdoms much resemble each other. Some
Animals breathe by Lungs, others by means of Gills, & others
* In the mode of propagations Animals come near to Vegetables &
besides these general coincidences, they have others more particular.

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from the surface of their bodies, by means of pores. *Spiracula*. In the
like manner Vegetables have Air tubes & Pores upon their leaves, and
Dr. Hengenberg discovered that Air tubes passed in at the Superior & came
out at the inferior part of the leaf, which was first hinted at by our
great Priestly. The Air in passing through Vegetables, undergoes
a change as it does in the Lungs of Animals, it becomes obnoxious
to them in consequence of being impregnated with fixed Air,
but this is congenial to Vegetables, so that if you put an Animal
nearly expiring, from having been confined in the same Air
for a long time, they will revive the Animal, & protract his life
by absorbing the fixed Air. Thus the Animal & Vegetable Kingdoms
counteract the impurities that would be produced by either of them
singly. Another part of coincidence between Animal & Vegetables
is observed with respect to sleep. Animals are well known to
be thus affected; and the Corolla of Vegetables are well known to
roll up at certain times, & this from not an abstraction of light
or heat, for the effect takes place in hot houses. It was said that
heat expanded the plant during the day, & when the Stimulus was
removed that they of course collapsed; but this is not well founded, as
they would not collapse at night in the equal temperature of a hot house.
Both Animals & Vegetables possess irritability. This susceptibility of
being acted upon by Stimuli. Some plants thus acted upon,
as the Sensitive, have a kind of Muscular Motion & others have
particular Motions when the Sun shines on them, so that Vegetables

seem to approach in having the power of motion, for the Polypus has
 little more life than the Vegetables before mentioned. There is an
 American Plant called *Diantha Muscipula* or Venus's Fly-trap
 which has this kind of motion in a very particular degree, it
 secretes a fluid on its surface ~~which~~ which secretes the flies about
 it, & as soon as they touch it, it contracts upon them. Any substance
 applied to this plant will call forth a similar affect. Some plants
 have power of motion without any Stimuli being applied, & it is
 difficult to say wherein this differs from the Voluntary motion of
 Animals further than their instinct & in which Animals & Vege-
 tables seem to agree. No one will deny but that Animals possess
 this faculty in a certain degree, but it being possessed by Vegetables
 may deserve our notice. The Vine or Kidney bean, will naturally
 stretch out to grasp any body near them, as if conscious of their
 own inability to support themselves, & will even change the
 original direction in which they were growing if the stick be
 placed in an opposite one for them to cling too. If Trees are planted
 so near a ditch, that their roots must spread out of the Earth, it is
 observed that as soon as they appear on the surface that they dip
 down again into the Earth; & in other instances they are observed to seek
 out that particular structure of the Earth that suits them best. A Cucum-
 ber if growing in one direction, & a wet sponge be applied in an opposite
 one, it will change its course & grow towards the Sponge. No Vegetable
 has the power of Loco Motion, neither has the Oyster, so that this

therefore will not distinguish them, & there is an Indian Plant
called the walking plant, which is observed to turn & completely
to change the direction of its leaves, but this depends on the sti-
mulus of light. Like Animals they have the power of repairing
injuries. When an Animal is wounded, Lymph is thrown out,
& this seems to be the medium of bringing the parts together, the vessels
shooting through & thus again uniting them. In the like manner when
a vegetable is wounded sap is thrown out & seems to answer the
same purpose. The same coincidence is observed in animal & vegetable
propagation. The Polypus will propagate by cutting, & in like manner
vegetables propagate by slips or by cutting, as in the Potatoes. The natural
propagation of Polypus is by tubercles forming on its back which after
a time separate & become living Animals. According to the Linnæan
System there are Male & Female plants, & they propagate by Sexual
intercourse. In what are called Hermaphrodite Flowers, there are both
Male & Female organs, & sometimes there are several Female organs to one Male.
In the Male the testis seems to answer to the Testes of Animals & the Vasina
furnishes the Semen. In the Female the Pistil answers to the Fallopian tubes,
& the Perispermium to the Uterus. The mode of receiving nourishment is
also in some degree alike in Animals & Vegetables; the Placenta of the
Bear furnishes food until the evolution of the roots & children are not
nourished by a communication of vessels, between the Child & the
Placenta, but blood is taken up by vessels from its Cells, much as the roots
of Vegetables absorb nourishment from the Earth. They agree also in

other instances. Having pointed out so many coincidences between Animals & Vegetables the question naturally arises wherein do they differ & how can we certainly distinguish one from the other. Let us endeavour to draw a line of distinction from the manner in which they receive their food; if fluid it is absorbed by the roots of Vegetables & distributed through the numerous tubes for the nourishment of the Plant, after having undergone some changes. On the other hand all animals, even the Polypus, have one or more Cavities in which the food is received, & which we may call a Stomach; here it undergoes an entire change & this we call digestion. After the food is thus digested, it is taken up by the Lactals for the nourishment of the Animal. Hence the grand marks of distinction are that in the Vegetable, the food is ready for nourishment immediately as it is received; whereas in Animals it must undergo the process of digestion, & that in Vegetables it is received by the roots, while in Animals it is received into a particular cavity called the Stomach.

Lecture 3^d

On the difference arising between Animals and Vegetables by the addition of the Vital principle of Life.

To ascertain the above mentioned, it will be necessary first to enquire what life is. Physiologists not being able to give a

direct definition of it, have made use of different analogies to express their Ideas of it. Some have compared it to a Spring of a Watch; for they say though every part of the Watch be perfect, yet if it wants the vital principle or Spring, it can no longer go. But the comparison must appear very faulty, when we consider the Spring of a Watch to be composed of matter, & that it acts on Mechanical principles.

Others have illustrated it with Magnetism, but with little success. Others have again compared it with Electricity, but this acts Mechanically by attraction, & repulsion in a uniform degree, while the actions of life vary as much as the different organs. Hence all these comparisons are inadequate to the definition of life. We can form no idea of life but as connected with matter, & it exhibits great variety according to the kind of matter with which it is combined. Nothing gives us so great an idea of it, as when combined with Animal Matter. A distinction must be made between matter and Life. When an Animal moves we doubt not the existence of life in it, but it does not follow that when motion ceases, that life ceases also. If so when action ceased as it does during the suspension of respiration, by Hanging or Drowning, it would put it out of human power to restore life, as that requires the powers of Creation. Some Animals, as also some vegetables have no apparent action; for instance the Egg & the Seed, yet these seem to possess life. If an Egg which has received the influence of the Male is placed in a certain degree of Warmth, for a certain time, a Chick is formed, now warmth would

not have this effect if life had not existed in the Egg, for suppose it had
 not received the influence of the Male, putrefaction would be produced
 by warmth instead of life. The heat therefore produced by incubation
 does not impart vitality to the Egg, but stimulates & calls it forth into action
 that Vitality which preexisted. The vital principle in an Egg may be de-
 stroyed by cold. If you expose an Egg to such a degree of cold as to freeze
 it, & then place it under the Hen, putrefaction will soon take place, so
 that there seems some distinction between life & action. If we attempt
 a definition, life the intellectual faculties cannot be admitted as essential
 to it, for this almost all Animals would be excluded. These qualities
 are only to be enumerated in the definitions, which are absolutely for
 the thing defined, & without which it could not exist. Therefore the
 power of propagation must be excluded, as well as the intellectual
 faculties, for Man has not the power till arrived at a certain Age,
 & often Animals have it in common with him. Is sensation to be
 admitted into the definition? No, for life remains during sleep,
 when sensation as well as ~~life~~ volition are absent. Involuntary action
 cannot be admitted essential, for we have no reason to think that
 it exists in the Egg, & reasons have been given for supposing that
 life exists in it. Some have thought that the power of resisting
 cold & heat, & preserving temperature is a proper definition of
 life. Several experiments have been made by Dr. Fordyce
 which shows that this power exists in a great degree in Man.
 The Doctor heated rooms to different degrees of temperature, and

going into them one after another gradually, he fully proved the temperature cooler than the Air in the room, or in the Urine he voided there. He carried the experiments to a great height & heated one room within ten degrees of the boiling point; & in which an Egg & a beef Steak were heated dry. During the time that he was in the room, he observed streams of Moisture trickling down his face. This might by some be imagined to arise from the great heat of his body, producing a larger quantity than usual of the perspirable matter, but on the contrary, it was proved to be owing to the condensation of the heated Air in the room, which rested on his body as a colder medium. Amphibious Animals have this power of resisting temperature in a slight degree. Serpents have it more than Frogs; Frogs than Fish, Snails have very little of it, & worms & Leeches none; Birds have less of it than beasts. Does it arise from Vitality or a particular organization? From the latter; because different Animals are found to resist variations of temperature in proportion to their complicated structure. Some have rested the definition of life on the power of resisting putrefaction. It is true that as long as the Vital principle remains, that the causes which would produce putrefaction can have no effect; neither does a body become putrid as soon as life ceases. Others define it to be a power resisting freezing. Mr. Hunter exposed two Eggs to cold, one which had been frozen before, and which again becomes so sooner than the other. This shows that living matter has in itself a power of resisting freezing, but this distinct con-

has before been shown to be insufficient. The difference then between dead & living matter seems to be, such a disposition to action, as may be called forth by the application of a proper stimulus. Thus the Egg & seed have this disposition to action, which may be produced in one by the application of heat, & in the other by the application of Earth. When we speak of action, we do not mean any particular action, as of a Muscle or Nerve, by action in general. We may here also distinguish action from Motion, for inanimate powers may be made to possess Motion. With respect to Stimulus no particular kind is meant; for what may be a stimulus to one body, may not be so to another. But whatever has the power of exciting Animal & Vegetable Matter to action, on the application of Stimuli; we offer a definition of Life. It is true that this approaches near to inevitability, but we do not confine ourselves to muscular actions, we extend our definition to all organized bodies. We shall now say something of the connection of action with the System. When action is begun, it is necessary for the preservation of life, that it should continue. We will then to say when action is suspended by Hanging or drowning that we breathe into the nostrils the breath of life. No, after the suspension of action, there is a small interval between it & death, the length of which depends on various circumstances. A certain degree of action is only necessary for the continuance of life, & in some instances a very small one. We denominate a Stimulant. Thus then the disposition to action,

Maturation of fruit goes on after it is separated from the tree, but if any
 part be bruised so as to destroy action that part will putrify, hence it
 seems that although action & life are two different things, that they
 cannot long exist separate. The connection between life & action varies
 much, being stronger in some Animals which are small & growing
 gradually weaker as they approach in size. Thus it has been before
 said, that the Polypus has been cut to pieces, & each piece becomes
 a new Animal. Worms after being divided will unite & live; a snail
 will live after his head is taken off & some say that a new one is formed.
 I have seen one live three weeks after the operation, & there seemed a
 considerable attempt at forming a new head. Many Amphibious
 Animals will live three or four hours after their hearts are taken out. If
 the large Artery in the Leg of a Hog be divided, nature of her own accord
 will stop the Hemorrhage. Many parts of a Man may be cut
 through without any injury to the vital principle, but some
 parts being stronger would bear it better than others. Parts
 may be considerably weakened & yet restored to their former
 action. But in such cases care must be taken that the Stimulus
 applied be not too violent, otherwise the action produced, will be
 too great, & mortification probably ensues. It seems that Animals
 possess very different degrees of life, & that man possesses less than
 most others, & is less tentative of it. The reason of which seems to
 be, his being endowed with a superiority of Mental power, to
 secure himself against injuries.

Lecture 4th

A comparative view of Man and other Animals with respect to their Food.

We have hitherto considered matter, as being divided into three kingdoms, Animal, Vegetable & Mineral. In doing this it appeared that the two former were endowed with a power of growth, & had also various secretions. These of course must exhaust the nourishment that is taken in for support, & consequently fresh supplies must be frequently required. The principal cause of exhaustion are, the Urine, Stool, Saliva & Perspirations, & to these may be added the actions of the body & mind. Nature to provide for exhaustion that must arise from the various secretions, has constituted a set of organs for receiving & circulating the nourishment. Various are the kinds of nourishment made use of, but it is derived from the Animal & Vegetable Kingdom. Some Animals live only on other Animals, some on Vegetables & some on both. This variety does not seem to arise from any whim, or caprice in the Animal, but from instinct, dependant on the structure of the organs for Mastication & digestion, & by which each Animal is undered capable of extracting nutriment from his peculiar food so that by examining, the teeth & intestinal Canal you may at

once determine on what kind of Food the Animals live. Man is one of those that lives on both kinds of Food or either. Some digest Animal food with difficulty, while others with equal difficulty digest Vegetables. Vegetables derive their food from Air & Water, but this contains so little nourishment that but few Animals can be supported by it. Gold & Silver Fish seem to be of that number, & it appears they are not supported by the Animalcula which may be in the water, for they will live in distilled water equally well, & are found not only to grow but to discharge Feces. The Vegetables that are the most nutritious are first those that abound in farinaceous matter as grain & Potatoes. 2^{ndly} Those which abound in saccharine matter, as the Sugar cane & Carrots. It is observed that the blacks when they cut the canes are fatter than at other times. 3^{dly} Those which contain essential oils & Gums. The Mucilaginous parts of Animals contain most nourishment, the dry part very little, & Animal fat much more than Muscle. What shall we say is the principle which nourishes? Some have said that it is mucilage, but it is better to call it the nutritive principle. To extract this principle from food, & to convert it into Chyle is the business of the digestive organs, assisted by the Masticators, the grosser parts passing through the Alimentary Canal. Animals as was observed before, are instinctively led to some kinds of food, from a peculiar organization, depending on the teeth & Alimentary Canal; Carnivorous Animals have sharp pointed teeth to tear their food to pieces,

Those that are fed on grain or other Vegetables have teeth with broad irregular surfaces, for grinding their food more easily, & they have a lateral motion in their Jaws. The teeth of Carnivorous Animals have the enamel on the outside, but in the Gramivorous Animals it is mixed with the substance of the teeth, so that the surface will still grow more uneven rather than the contrary. Man is so adapted in this respect, as to be able to digest both Animal & Vegetable food. This appears from the form of the Stomach, & indeed from all the organs that have to do with the food. The Stomach of Gramivorous Animals is very large, as in the Cow, Sheep, Goat, &c. which Chew the food, & they have more stomachs than one. The reason of this is obvious, for as Vegetables contain much less nutriment than Animal Matter, a greater quantity is required to be taken in. The Intestinal Canal in these Animals, is for the same reason much longer, that the food may be longer in passing & by that means a greater time be given for the extraction of the Nutriment Matter. Those Animals on the contrary which live on Animal food have a small Stomach, & Intestinal Canal. Carnivorous Birds have a very small but strong Muscular Stomach. The human Stomach & Intestinal Canal are between both extremes, hence it appears that Man was intended to live on Animal & Vegetable food combined, though we may be nourished by either alone. Among the Gentoo, whose religion forbids the eating of Animal food their living is entirely on Vegetables, but they are a Meagre & timid people. In Lapland again

where the soil is too barren for Vegetables, the Inhabitants live wholly
 on Animal food, & are a very hardy & robust race, but in most
 Countries Man lives on both, though in different proportions.
 Generally, most Vegetable matter is eaten in warmer climates, &
 the contrary in cold countries. Animal food is necessary for those who
 are accustomed to hard labour & should be taken in proportion to that,
 but it is not favourable for intellectual pursuits, for although it invi-
 gorates the Body, it clouds & stupifies the mind. Before the food is
 taken into the Stomach it is necessary it should be first Masticated.
 To perform this there are some very strong Muscles to shut the
 Jaws; viz. The two Temporal, two Masseters, & the two Pterygoid,
 to make Mastication easy there is in the human Jaws, as well as in
 Graminivorous Animals a lateral motion. On the Articulation
 of the upper Jaw with the lower one, there is a moveable Cartilage
 which allows this motion to the lower Jaw during the Mastication
 of food. Several fluids mix with it, as well as to facilitate that process, as
 to assist digestion. Ruminating Animals have several Stomachs,
 they, after Masticating their food a little, deposit it in their first
 Stomach or Pauch, where it macerates with a fluid contained
 therein. After thus sufficiently macerating it, they have a power
 of making it regurgitate. They then chew it again & pass it
 into the second Stomach & from whence it goes to the rest. To illus-
 trate this it is found that the Oesophagus of the Cow communicates
 with the two first Stomachs, & that the Animal has the power of passing

its food into any of them at pleasure. Then when the food has been triturated a little, it is deposited into the first Stomach to macerate; after maceration it regurgitates & is again triturated more minutely. It then without going into the first, passes through the second Stomach into the third, & from thence into the fourth, where it is digested. The two first Stomachs do not seem to have any share in digesting the food, but it is merely preparatory to that purpose. Liquids not requiring Mastication, pass into the second at once, without going into the first. Birds have a peculiar way of masticating their food, those of the Carnivorous kind do not masticate it at all, but only tear it in pieces. The Birds that feed on grain have no Stomachs, but receive their food into a bag, called the *Ingluvis* or *Crop*, where it is softened by macerating with a fluid. Ducks have no *Ingluvis* but an enlargement of the *Esophagus*. The food passes from the *Ingluvis* into the *Gizzard*, which is composed of two strong Muscles, & is grown down by the action of that organ; the sharp pebbles that the Bird takes in assisting in that process. The pebbles or sand taken in are proportioned to the size of the Bird. Thus the Ostrich takes in stones of one size, Poultry smaller, & Birds ~~some~~ only sand. As the pebbles grow smooth by friction, the Bird instinctively avoids them, & takes in others. If you open the *Gizzard* of a Pheasant when triturating its food, the motion of it is not very visible but may easily be heard. To prevent the bad consequences that might arise to a Muscle from the sharp points of the Pebbles,

the Gizzard is lined with a thick horny substance. Some have doubt-
 ed that either pebbles or sand assist the Gizzard in grinding its food.
 The able Spallanzini for a better reason says, that the Pebbles are
 taken in by the Birds from mere stupidity. To ascertain this the
 experiment was made, by keeping some fowls from a sandy
 matter, Pebbles &c, & it was found that they grew very thin, which
 proves that their food did not yield so much nourishment. Crabs
 are said to have teeth in their Stomach, where they masticate their
 food. Some have thought the Gizzard an organ of digestion, as
 well as mastication, but this does not appear to be the case, for
 that fluid necessary for digestion has never been found, nor is its
 external surface a secreting one, although there are some glands
 in it. In the digestion of Birds it seems to be going on at the origin
 of the Intestines. It was observed that during mastication, several
 fluids mixed with the food, the principal of these is the Saliva.
 The Saliva is secreted by six glands, each of which has a duct
 terminating in the Mouth. The ducts of the two Parotids terminate
 in the side of the Cheek, opposite to the Molar tooth.
 Those of the two submaxillary immediately under the tongue.
 These may be made to secrete a large quantity of Saliva
 in a short time. Eating very much increases it. I have forgotten
 to mention that the two sublingual terminate on the side of the
 tongue, but the submaxillary do much nearer the penum. Food
 of a fluid nature does not increase the secretion as much as solid

food. Some Medicines as Tobacco, Mercury, &c, increases this secretion. Attempts have been made to ascertain the quantity of Saliva discharged at a meal. During that time several quarts have been discharged from one duct that was divided, but this method of computation must be very uncertain. The secretion however in a given time being very great, they must be supplied very plentifully with blood vessels. The Arteries that supply these glands ramify minutely through their substance, & then terminate in small Cells. From these Cells arise a number of small ducts which terminate in the principal duct, which we observed to terminate in the Mouth. Besides these there are a number of small glands within the Lips, called the Labial & about the tongue & palate which secrete a mucus from Follicles. The fluids from these various glands not only assist in Mastication & facilitate Deglutition, but seem also to have some share in digestion. That they assist in digestion appears from this fact, viz, that people who spit much are often affected with Dyspepsia. Their use in deglutition is not less evident; for when the glands are destroyed by Venereal ulceration, the secretion being no longer kept up causes a dryness in the fauces & obliges the patient frequently to moisten his mouth during the time of swallowing. When the food is sufficiently Masticated & ready for deglutition, it is formed into a kind of bolus, this we put into the Centre of the mouth, & towards the back part of the tongue, & so far this is a voluntary motion

or action. but when the bolus is there placed it is subject to the action of involuntary Muscles which propel it. When we look at the back part of the mouth, we observe two arches; the first of these is the constrictor isthmus faucium, & the other the Palato-Pharyngeus Muscles, which chiefly propel the food in this part, though they may be assisted by some that are situated thereabouts. It may be asked why the food after it has been swallowed, does not pass into the Trachea or regurgitate into the Nose? At the root of the Tongue there is a small flexible Cartilage standing up called the Epiglottis. The food in passing down presses this on the Glottis, but the more completely to close it up; there are muscles which draw the Larynx & Pharynx, & consequently the Glottis is raised at the same time that the Epiglottis is depressed. That the Trachea is thus closed appears from our getting food into it when laughing or speaking, & at which time Air rushes out from the Lungs & must consequently open the Glottis. The food is prevented from regurgitating into the Nose by a fleshy substance at the posterior part of the Mouth called Velum, Pendulum Palati. This is chiefly formed by the circumflexus & levator Palati, the latter of which draws the Velum Pendulum Palati. Venereal Patients who have had it destroyed, have their food more frequently regurgitated than others by the Nose. The food is propelled by the two arches before mentioned into the Pharynx, where it is still pushed forwards by voluntary Muscles & does not descend by its own gravity as appears from grazing Animals. The Pharynx has two

orders of Muscles, the one longitudinal the other transverse, the former shorten the Pharynx, while the latter propels the food by contracting upon it, & thus it is carried by the course of the Oesophagus into the Stomach.

Lecture 5th On the Structure and Functions of the Stomach.

We now proceed to consider the action of the Stomach on the food. After the food has passed into the Stomach it loses the character of Masticated food, & becomes a uniform pulpy Mass. If we examine an Animal soon after being fed, we find that part of the food, which is nearest the orifice of the Stomach, to be very little altered, but as it descends lower it is gradually more & more altered, & that which lies near the Pylorus is the uniform pulpy mass before mentioned. From the gradual change in the food in passing through the Stomach, it is evidently affected by that organ. The food thus altered is said to be digested, & hence we call the Stomach an organ of digestion. But after the food has been digested it must pass into the Intestines, to undergo a still further change, which leads us to consider the Stomach as a muscular organ. We find also that if any material injury be done to the body, that the Stomach will often be

affected, & thus lastly we shall consider the Stomach as an organ
 of Sympathy. The better to understand the Functions of the Stomach,
 we will first take a view of its Structure; not however ~~with~~
 with the minutiae of an Anatomist, but so far only as it will
 assist in illustrating its Physiology. The figure of the Stomach
 has been compared to that of a Bag pipe; it is situated somewhat
 obliquely in the Epigastric region, & has two orifices by which
 the food enters & goes out, the recipient orifice is called the
 Cardia; the expellent the Pylorus. The Stomach we know has
 a muscular power by which it expels the food, but from its
 oblique situation the gravity of the food itself will assist in its
 expulsion. The degree of obliquity is not great; some might think it
 would be of advantage if it was greater, as the food would then
 pass more readily, but was this the case it might be conveyed
 to the Intestines before digestion was completed. The Structure of the
 Stomach is not alike in every part, the Vessels are not so minutely
 distributed to some parts as to others. It is covered by a smooth
 Membrane the ~~Peritonaeum~~^{Peritoneum} in common with the other Viscera, when
 it is stripped off, we find a number of Muscular fibres running in
 various directions, some longitudinally others transversely, & some
 between both. When these are removed there appears a thick cellular
 substance called its villous coat. The coat of the Stomach is capable
 of secreting a fluid, & hence those who annex ideas of Glandular
 Structure to all secreting organs might think it should be called

a Gland, but we do not find any glandular structure in the Stomach. It is a kind of Law in the Animal economy that every part should be supplied with blood, from the large Arteries lying contiguous to it; thus we find the Stomach supplied with blood from the large branches of the Hepatic, Splenic. & Coronary Arteries, which terminate in the villous coat. That this is the seat of Secretion, appears from the termination of Arteries being capable of secreting as well as Glands. As the Stomach is plentifully supplied with blood there must be veins to return the superfluous quantity & these terminate in the Vena Portarum which supplies the Liver with blood. The Stomach has likewise Absorbents which have a peculiar termination, for instead of going to the Thoracic duct they terminate in Veins. This I have ascertained by injection, & have found it confirmed by eminent Anatomists. The Nerves which are distributed to the Stomach come principally from the Par Vagus or eighth pair of intercostal. Now that we have taken a view of the Structure we are better prepared to consider the functions of the Stomach. We will first briefly relate the different Theories that have been held respecting digestion. Hippocrates supposed digestion to be carried on by heat, produced by the larger Viscera which surrounded the Stomach, & by moisture as it were. *The branches of the Par Vagus are distributed to the left extremity, & the right are supplied by the intercostal - - -

stewed the contents. He thought this the sole agent but this is
 considering digestion in a very confined light, & it will be proper to mention
 one objection to it. There are certain Animals called cold blooded, as
 frogs, the heat of whose bodies is very little above the temperature of
 the Medium in which they live, & digestion is found to go on
 perfectly well in them. But although heat be not a principal
 cause or agent yet it must certainly be considered an Auxillary in
 the process of Digestion. Another theory was, that it was performed by
 putrefaction, but we do not find the smallest part of the digested food
 putrid, on the contrary if food a little putrid be taken into the Stomach, it
 will be meliorated more than it otherwise would & some have said, that if even
 quite putrid, it would be rendered sweet again in the Stomach. The next
 Theory that engaged the attention of Physiologists was that of Erasistratus, who
 supposed that digestion was performed by trituration, he took this
 idea from Birds, & thought that man did the same. But the structure
 of the human Stomach is such, that it certainly could not perform
 this office. The Stomach of some Animals is still thinner & hence we
 may conclude that Erasistratus did not distinguish between Mastication
 & Digestion. But a Theory which prevailed last century, & which still
 has its advocates, is that digestion is similar to Fermentation. In the
 last century all the secretions & other actions of the fluids, were
 attributed to Fermentation. Boerhave exploded the opinions with
 respect to secretions, but thought that it still had something to do with
 Digestion. Several eminent Physiologists have entertained this opinion,

but they seem to annex peculiar ideas to fermentation, very different to those of Chemists. A Chemist would say that various gasses, are evident & evolved in fermentations, & therefore that the fermenting substance should be exposed to the Air, & that different substances would be produced according to the different ingredients which were fermented, whereas the food in the Stomach is shut out from the Air, & the Air & the substance produced by digestion is universally the same. (Chyle) whatever ingredients be taken into the Stomach. The late Sir John Beingle & Dr. Mc Bride made many experiments to support the Theory of Fermentation. They put many different substances into a Vessel, to which they added warm water, & to render as they supposed the experiment more complete they added a quantity of Saliva. They then exposed the Vessel to a degree of heat very near equal to the human body, for some time. This they thought a mass similar to digested food; but they forgot that the Stomach itself secretes a fluid or they thought it of no consequence in digestion. The following experiment however may illustrate the importance of the fluid. I fasted a dog 18 hours & killed him. On opening the Stomach I found a quantity of Gastric juice. I collected half an ounce of it. To a part of this were added 12 grains of roasted Beef; another quantity diluted with a little warm water, & Beef put in it also. I put both Vessels into a degree of heat equal to the human. In the first vessel in 8 hours the Beef was almost dissolved but that in the other very little altered. In 24 hours the Gastric Liquor entirely dissolved the Beef without

any appearance of fermentation, but the water & liquor mixed produced no alteration in the meat, & a little color was perceptible in it. It is now therefore pretty well ascertained that digestion is performed by solution on chemical principles. Reaumur was the first who made experiments to prove this. He introduced food in metal tubes into the Stomach of the Animals, & on opening them, he found that it was dissolved. Those who are advocates for fermentation say if the Gastric Juice has the power of dissolving Animal substances, why is not the Stomach dissolved by it. The Stomach is in fact sometimes dissolved by it, but not while vitality remains. To Mr. Hunter we are indebted for this discovery, he found several times the contents of the Stomach in the Abdomen when dissecting & has many preparations of the Stomach; some of which had a part corroded. Others had holes eaten in them, & in one the left extremity was entirely destroyed. As we find the Stomach acted upon by this liquor in such different degrees, it may be asked what are the circumstances that favor it? A healthy & vigorous state of secretions at the time of death. Hence the Stomach has been found most frequently corroded in executed subjects, or such as have died suddenly when in a state of health. In such the fluid is already secreted, & as soon as life is gone is capable of acting on the Stomach. But those who die after disease, & having little appetite & a languid circulation, have consequently a very small secretion of this fluid, & this accounts for the Stomach not being found oftener in a state of dissolution. The Gastric juice will act on earth worms, or Snails if taken into the Stomach,

but not while vitality remains in them. It might be objected to Beaumont's experiments that they were made only on inferior Animals, but Dr. Stephens of Edinburgh has had an opportunity of repeating them on the human subject. The Doctor in an inaugural dissertation concerning digestion, published at Edinburgh in the year 1777 made several experiments upon a German, who gained a miserable livelihood by swallowing stones for the amusement of the People. He began this strange practice at the age of Seven, & had at that time continued it for about 20 years. He swallowed six or eight stones at a time some of them as large as a Pigeons Egg, & passed them in the natural way. Dr. Stephens thought this poor man would be an excellent subject for ascertaining the solvent power of the Gastric juice in the human stomach. The Doctor accordingly made use of him for this purpose. He made the German swallow a hollow silver sphere, divided into two cavities by a partition & perforated with a number of holes, capable of admitting a common size Needle. Into one of these cavities he put four scruples & a half of raw beef, & into the other five scruples of raw Bleat. In 21 hours the sphere was voided; when the Beef had lost 16 scruples, & the fish two scruples. A few days after, the German swallowed the same sphere, which contained in one cavity four scruples & four grains of raw, & in the other four scruples & eight grains of boiled Beef. The sphere was returned in 43 hours; the raw flesh had lost one scruple & 2 grains, & the boiled one scruple & 16 grains. Suspecting that if these substances

were divided the solvent would have free access to them, & more of them would be dissolved; Dr. Stephens procured another sphere with holes large enough to receive a Crows quill. He inclosed some beef in it a little masticated; In 38 hours after it was swallowed it was voided quite empty. Perceiving how readily the chewed meat was dissolved, he tried whether it would be dissolved equally soon without being chewed. With this view he put a scruple & 8 grains of Pork in one cavity, & the same quantity of Cheese in the other. The Sphere was retained in the Germans Stomach & Intestines 43 hours, at the end of which time, not the smallest quantity of Pork or Cheese was to be found in the Sphere. He next swallowed the same Sphere which contained some roasted Turkey in one partition, & some boiled salt Herring in the other. The Sphere was voided in 46 hours, but no part of the Turkey or Herring appeared, for they both had been completely dissolved. Having observed that Animal substances though inclosed in Tubes were easily dissolved by the Gastric juice; the Doctor tried whether it would produce the same effect upon Vegetables. He therefore inclosed an equal quantity of raw parsnip & Potatoes in a Sphere. After continuing 48 hours in the Alimentary canal, not a vestige of either remained. Pieces of Apple, Turnip, &c both raw & boiled were dissolved in 36 hours. Dr. Stephens inclosed live Leeches, Earth Worms, in different spheres & made the German swallow them. When the Spheres were discharged the Animals were not only deprived of life, but

completely dissolved by this powerful Menstruum. Hence if any live reptile should chance to be swallowed, we have no reason to apprehend any danger from such an accident. The German left Edinburgh before the Doctor had an opportunity of making a further progress in his experiments. He therefore had recourse to Dogs & Ruminating Animals. The able Spallanzani, confirms these experiments & says that digestion is always performed by a solvent, however different may have been the mode of Mastication.

Lecture 6th The Source of Gastric Juice.

We shall now proceed to make some further remarks on the Source of the Gastric Juice. In the human subject & in most Quadrupeds of the Carnivorous kind, it seems to be secreted from every part of the internal surface of the Stomach it being almost equally vascular, in almost every part. Some have said that the Oesophagus also yielded part of the secretion but this is erroneous for it has no villous coat. But in the house Rat &c the secretion seems to be confined to the right side of the Stomach only, which is villous & secreting. In these animals the Stomach is lined with a Cuticle, which is continued half way down, & where this ends, the villous coat begins. The termination of the one,

and the beginning of the other coat is not confused but distinct & well marked. The secretion being confined to the Villous coat, the other is only slightly vascular. It must be supposed that digestion goes on very slowly in these Animals, & it seems very probable that one half of the Stomach, serves as a recipient, while the other performs the office of a digesting organ. In ruminating Animals it was before observed that there were four Stomachs, but all these do not secrete the Gastric Juice, the three first seem peculiar to them as ruminating Animals, but the fourth differs from them in structure, being much more vascular. It is by the last that the Gastric juice is secreted & digestion performed. It is this Stomach dried with the Gastric juice, which is used in making cheese & is called Rennet. It does not appear that the Gastric Juice curdles Milk by its acidity, if it did we might suppose it dissolved the food like other strong acids. Its properties & the manner in which it acts upon the food, cannot be discovered by any Chemical process. When infants as is very common throw up curdled Milk, it is not a necessary consequence of acidity in the Stomach, for we see that the Gastric Juice, has the power of curdling Milk. In ~~Graminivorous~~ Birds, the Gastric Juice is secreted in the bulbous part just above the Gizzard, or rather by small Glands that have small ducts terminating in the internal surface of the bulb. The fluid is mixed with the food, before it enters the Gizzard, & is afterwards triturated & digested at the same time. There is a similar apparatus in

Carnivorous Birds for secreting the Gastric Juice, but the
 Glands in them are smaller & more numerous. The Animals
 who have not a Gizzard, but a strong Muscular Stomach, this
 fluid is discharged by small excretory ducts, on the internal
 surface. With respect to the Granivorous Birds it might
 perhaps be more properly said, that the food is ground down &
 intimately connected with the Gastric Juice in the Gizzard, but that
 digestion is finished in the Duodenum, before the entrance of the
 Ductus Communis Choladoch & Pancreatic ducts in Birds than
 in other Animals. In cold blooded Animals as the Serpent, the
 secreting part of the Stomach is very small. In these it is difficult
 to say, where the Oesophagus ends, & the Stomach begins, for
 they are both nearly of the same size. The lower part of the
 Stomach is very vascular, & it is there the Gastric Juice is secreted.
 Digestion in these Animals is very slow, for they swallow
 Animals nearly as large as themselves, and the Stomach
 being more narrow, only one part of these can be acted upon
 at the time, so that the Animal may remain in the Stomach
 some days before it is entirely digested. The Gastric Juice not
 only acts on Vegetable & Animal substances, but will also dissolve
 Metals; thus we know that if crude Mercury is minutely divided,
 it will be dissolved in the Stomach. Chemical Analysis has
 shewn crude Sal Ammoniac & Muricatic Acid, to be contained
 in this fluid, but this does not explain its effects. It is best therefore

to say, that it is a strong solvent even for bones as we see in Dogs and Metals; the Nausea excited by taking copper in consequence of its Solution, & that it resists Fermentation, & is therefore what Chemists call an Antozymic. The Gastric Juice is subject to be changed in its properties by various causes which may accidentally occur, & among these are the affections of the mind, thus if a person while eating is acquainted with any distressing news, his appetite is immediately gone, or if he has been eating & the digestive process is going on well, it is nearly or entirely stopped. Hence arise acidity, flatulency, & Eructations. Hence Hypochondriacs, have these & other symptoms of Dyspepsia. The effects from the mind to the Stomach are conveyed by means of the Nerves. Of these the Par Vagus is passing through the neck in the course of the internal Jugular Vein, & after giving off several branches in its way supplies the upper orifice of the Stomach. The lower part is supplied with nerves by the intercostal or grand Sympathetic Nerve. Baron Haller says if the Nerves going to the Stomach be tied or divided the food will become putrid but my experiments did not produce this effect. In order to ascertain how far the Nerves were concerned in digestion. I endeavoured to intercept the communication of Nervous influence between the Stomach & Head. To do this I divided the branches of the Par Vagus in a Dog after he had taken food. He died in two days & opening the Stomach the food was found in every part dissolved. Now in health we know the food will be digested in 24 hours. It appears

therefore probable that the little solution which had taken place
 was performed by the Gastric Juice secreted before the division of the Nerves,
 & that after this none was secreted. To another Dog, I gave a strong
 Emetic, & when it began to operate, I injected warm water so as per-
 fectly to wash out the Gastric Juice. The Dog not being inclined
 to eat after the operation of the Vomit, food was forced down his
 Oesophagus. I afterwards divided the *Par Vagus* as in the former in-
 stance. This Dog also died & the food was not in the least acted
 upon. It appears then that the division of the Nerve either entirely
 prevented the secretion of the Gastric Juice, or so far vitiated
 it as to destroy its functions. In a third experiment on
 a Dog, I divided only one branch of the *Par Vagus*, but this
 did not seem to produce any material difference in the functions
 of the Stomach. The Dog seemed rather uneasy in his Stomach,
 but he eat well & his food was digested, about six hours after-
 wards, I divided the nerve on the other side; some time afterwards
 knowing that the nerve which had first been divided must be
 united by this time. But it appeared from the division of the
 other not to have perfectly recovered its functions. The Dog now
 seemed much more uneasy & distressed in his Stomach than
 before, & his appetite was entirely gone. This however gradually
 returned, & from feeding him on Milk in about 5 months
 he became able to eat things as before; during this time however
 he showed many symptoms of *Dyspepsia*. Eructations, and

Emaciation, &c. The inference to be drawn from these experiments is very evident. *Viz*, That the Stomach cannot perform its functions well without the assistance of Nerves; that you suspend the energy of the Stomach when you do that of the Nerves, & that one will be restored with the other. Heat & cold have evidently some influence on digestion, but this is limited, heat much assists it. This is evident by putting substances into two portions of the Gastric fluid, & setting one in the temperature of 100 degrees while the other is in that of the common atmosphere, when the former will be found first acted upon. Cold blooded Animals as Fish & Frogs, having their blood very little higher in temperature than the medium in which they live, do not digest well. Hence living Animals are often found in their Stomachs, & they live long without food their digestion being so slow. In warm weather they become torpid, & some take no food at all. If in this state food be put into their Stomachs, it will not in the least be acted upon. The cold it seems first destroys the nervous energy, in consequence of which the action of the heart & arteries is much diminished & the blood in the secretory organs being nearly quiescent they cannot perform their functions. This is a wise provision of nature, for in the torpid state, there being no exhaustion going on in the System, no secretions are wanted. If a torpid animal as the Hedge Hog, or Lizard, be put & eat heartily & digest their food well, but in cold weather they

in a warm room, the influence of the Sensorium is first reduced & gradually in consequence of this the Arteries of the body are reduced. Food will now be wanted to supply the exhaustion of the Machine, & therefore the Gastric Juice is secreted. If food is given to an Animal at this time, it will eat it with rapidity, & if no food be given it must die. Cold acts on the Nervous System & produces Torpor & sleep different from natural sleep. In natural sleep the action of the heart goes on, though sensation & volition be lost, but in this sleep no action whatever is taking place in the Machine. In Men & large Animals the digestive process is not much altered by variation of temperature, for they can resist the effects of heat & cold to a very great degree.

Lecture 7th Acidity of the Stomach.

There is often some acidity of the Stomach during digestion, and it may be asked whether this aids or retards the digestive process? The latter appears to be the case; and the acidity only appears to be accidental, for if we open the Stomach of an Animal in health there is no acidity found in it. What then does this arise from? It is the same that would take place in the same substance of the body? If this were the case, the more ascendent substances

were taken in, the more acidity would be then generated, but this is not found to take place. It seems then the acidity in the Stomach depends on some fault in the secretion of the Gastric Juice. Infants are very subject to acidity in the Stomach & this is supposed to be the case when it really is not, as may be inferred from what has been said in a former Lecture, respecting the coagulation of Milk. The acidity in the Stomach of Children may often be accounted for, from their being made to take an excess of food. This for a time may increase the secretion of the Gastric Juice, but must finally weaken it, for all increased action of excess, thus taken in by Infants is frequently made to regurgitate, & the milk brought up rather in a coagulated state, but this coagulation is not dependant on acidity but on the Gastric fluid itself. Milk is also coagulated before it is digested & indeed this seems necessary to digestion. The Rennet taken from the fourth Stomach of the Calf curdles Milk under heat, & on the same principle does the Rennet in the Childs Stomach. Some have carried their ideas so far as to say that coagulation is universally necessary for digestion, but we may be furnished by many kinds of food, which do not seem capable of it, as Beeths &c. Some kinds of food dispose the Stomach to acidity upon any little disorder in its secretion more than others; as all oily substances. Empyrenimatic substances also run on to acidity in the Stomach. The weaker the state of the Stomach, the more it is subject to acidity, & therefore the less nourishment is

obtained. But how is this Acid formed? Is it from a spontaneous change into acetous fermentation, or from a diseased state of the Stomach, which disposes it to a kind of acid secretion; & so soon is this secreted introduced in the Stomach, that it is difficult to conceive, how it can be a spontaneous change taking place in the food; for it arises much sooner than it would out of the Stomach. The Theory of a French Chemist with respect to acidity being produced by taking oily substances into the Stomach, was their becoming rancid; he said that rancidity was performed by the extrication of fixed Air, & that he would easily make rancid Oil sweet by the addition of this Air. He supposed the acid eructations so common in these cases were owing to the escape of fixed air. I have not tried the experiment of making rancid Oil sweet by the addition of fixed air, yet was rancidity caused by the loss of it, that would not be sufficient to account for the quantity of air discharged by eructations in disorders of the Stomach. Some have supposed that this Air was secreted by the Stomach. This Theory may stagger many but it is certain that Air is secreted in many instances, as in Tympanites, & also after death from putrefaction. There is a disease to which Women are subject to after delivery called Tympanites Uteri. Mr. Hunter also once found a gaseous fluid in a circumscribed tumor, which he could in no way account for, unless it was secreted there. In some fishes as the Cod there are

Air cells, or bags, which do not appear to have any communication with the atmosphere, but each cell is vascular, & they appear to be apparatuses for the purpose of secreting air. Why then may not the Stomach under particular circumstances have the power of secreting Air. Disorders of the digestive process arise from three causes. 1st from the indigestibility of food taken in. 2^d from the want of sufficient Mastication; and 3^d from the debility of the digesting organs. The last may be the two former, for the action of the Stomach being increased by them, is as it were overlooked; a proportionate degree of debility will necessarily succeed. Dyspepsia is generally the consequence of over distention, & hence it is that high living, as well as large eating are certain causes to produce it.

Actions of the Stomach. . . . After the food is digested it must be discharged from the Stomach into the Intestines there to undergo a further change into Chyle, before it is taken up into the mass of blood. We come now to consider the power by which this is performed. All motion depends on muscles, & of such structure we find the Stomach possessed. In order that the Stomach may expel its contents, these fibres must act in various & particular directions.

We shall consider therefore how they are situated, & how they perform that office. The Oesophagus has been observed is very Muscular, some of its fibres running longitudinally

and others transversely. When the Oesophagus enters the Stomach, its muscular fibres expand so as to cover the Stomach on every side, the transverse lines intersecting the longitudinal ones at right angles. When these fibres are in action it is evident that one set will shorten the Stomach while the other contract it, & it is by these principally that the office of expulsion is performed. There appears some muscular fibres that pass in a direction between these two, but they are not very apparent in most subjects. By these several fibres the food is expelled gradually lower & lower until it is discharged. If we open a living Animal and view ~~view~~ its Stomach the action is not very apparent. It is evident but not so well marked as some others. I have more than once opened living Animals for this purpose, & have observed the action of the right extremity of the Stomach to be much more evident than the left. Indeed in the left I could hardly perceive any motion. This may be accounted for by the Stomach becoming depressed about the middle, & therefore till it arrived at the right extremity the food would easily descend by its own gravity. About or a little below the middle of the Stomach, a circular contraction is seen, which gradually descends to the lower orifice of the Stomach & some way into the Intestines. The contracted line appears again on the Stomach, & descends gradually as before. This

motion resembles the creeping of a worm & is very similar to the
 Peristaltic motion of the Intestines. I wished to know the effects
 of Stimuli, & therefore made use of the Volatile Alkali as
 Chemical Stimulant & the scratch of a knife as a mechanical
 one, but I did not find the Peristaltic motion at all increased
 by them, the only effect was a local increase of action
 for a time. We find there is an agreement between the
 Muscular & digesting powers of the Stomach. This is a
 wise provision of Nature to prevent the expulsion of
 the food before it is digested. Sometimes the motion of the
 Stomach takes a retrograde course beginning at the Pylorus
 or rather the Duodenum. This generally produces Vomiting.
 That the contractions begin at the Intestines is obvious from
 the matter which is vomited; & it is most natural to suppose
 the Stomach would employ itself, with respect to the act of
 Vomiting by contracting. It was said by a Foreigner & confirmed
 by some experiments made at Edinburgh that the Stomach
 was distended in the act of vomiting. I could hardly suppose
 this, & I fancied there must be some fallacy in the experiment.
 I gave a Dog a scruple of Ipecacuanha, & when it began to
 operate I opened him, so as to lay bare the Stomach; & draw back
 the false ribs to prevent any pressure being made on it, I observed
 the Peristaltic motion in the Stomach, but the Dog
 could not vomit though he seemed very sick. I threw in some

Water, thinking there might be too little in the Stomach to enable
 the Dog to vomit, but still without any effect, & yet the Stomach ap-
 peared a great deal distended. To increase the sickness a solution
 of blue Vitriol was given, but vomiting was not then produced.
 It may be adduced as an argument against the experiment,
 that the Stomach was for a considerable time exposed to
 cold air, & consequently that its irritability must be diminished
 for it is known that when an Intestine has been exposed for
 a long time to the Air, its Peristaltic motion is destroyed. To
 obviate this objection I repeated the experiment rather under
 different circumstances; & after as in the first instance having
 exposed the Stomach, I procured an assistant whose business
 it was to keep warm water dropping upon it from a Syringe by
 which means I preserved the natural temperature of the parts.
 In this case the fauces were irritated, Chemical & Mechanical
 Stimuli were applied to the Stomach, & all other means that
 were the best calculated to promote vomiting, but without
 effect. From the result of these experiments, I think there
 must have been some deception in those made at Edinburgh
 & perhaps the Stomach was pressed upon by the false ribs.
 Probably also the sudden inspiration before vomiting, might
 give the appearance of distention in the Stomach. In the
 act of vomiting in the natural state, the Diaphragm is depressed
 & consequently both it & the ribs make pressure on the Stomach.

The Abdominal Muscles assist in the same intention. From these experiments I think it evident that no power of the Stomach alone can effect vomiting. I thought this also a fair opportunity of trying how much external assistance was required to enable the Stomach to expel its contents. I therefore placed my hand under the Stomach as a fixed point, but did not make any pressure, & the Dog instantly vomited. It seems that though the Stomach has not the power of performing that sudden & violent action of itself, necessary to expel its contents yet by the pressure of the Diaphragm & the Abdominal muscle can take place on the principle that the hand was applied in the last experiment. Dr Verrey & Dr Hunter were of opinion that the Stomach was totally inactive in vomiting. Mr Hunter's opinion was that vomiting was to the Stomach, what expectoration is to the Lungs. It is well known that the Lungs are not muscular. Expectoration is performed by a quantity of air being inspired, which being violently expelled by the muscles of expiration compressing the Lungs suddenly carries the Phlegm along with it. Now the Stomach is muscular, besides it does not appear that Air assists materially, if at all in the act of Vomiting; yet very little air goes into the Stomach, & we often vomit without making a previous inspiration. But can Dr Hunter's opinion be refuted by experiment? The Stomach it was said is Muscular, but muscles cannot act without nerves, we shall see then from the following experiment whether the Muscular structure of the Stomach is necessary in vomiting, or whether the Stomach is inactive as Dr Hunter supposed. I gave a Dog an Emetic & paralysed the Stomach by dividing the *Par Vagus* & *intercostal* nerves which go to it, and

though the Dog became sick from the Emetic, yet it was unable to vomit notwithstanding. There was the usual pressure on the Stomach, by the different Muscles. The experiment was repeated & the result was the same. This & the experiments before related, prove that neither the Stomach alone, nor the Muscles pressing upon it, are of themselves capable of producing vomiting, but that the power must be united. Some might draw an objection from particular Animals. Carnivorous Birds eat other Birds, with their Feathers, Talons & indigestible parts, & what cannot be digested they afterwards regurgitate. Now these Birds have no Diaphragm, but they have a Membrane which answers to it. Nature may provide some other means for their vomiting, & hence we should enquire, in what the Structure of their Stomachs differ from other Animals. We find they are much more Muscular, almost approaching to a Gizzard.

Lecture 8th

Of the Stomach as an Organ of Sympathy.

We now proceed to consider the Stomach as an Organ of Sympathy. It is not intended to enter into an enquiry into the doctrine of Sympathy, but it should be understood what we mean by the term. By Sympathy we mean sensation or action induced in one

part in consequence of an impression made on some distant part, the latter called the impressed ~~the~~ ^{the} the Sympathizing part.

We are now to speak of Sympathy only, as it is connected with the Stomach. The Stomach is sometimes the Sympathizing, & sometimes the impressed part. When there is a pain in the head, the Stomach is often affected, & on the contrary when the Stomach is sick, the head is often affected with pain. Some kinds of head aches depend on a morbid state of the Stomach; & we may know which is the Sympathizing part by observing which is the first affected. There is no part of the body except the Brain that has such extensive Sympathy as the Stomach. Every impression on the body whether pleasant or disagreeable is communicated to the Brain by means of Nerves which are distributed to every part. Hence the Brain may be said to sympathize universally. That this is the case may be proved by dividing a nerve, when it will be found that impressions made on such parts do not produce sensation, or that in other words the Brain does not sympathize with them. Nausea or vomiting is produced by many acute diseases, as Inflammatory Fevers; inflammation of particular organs as the Kidney, or by injury of some parts as the Brain. This is no other than the Sympathizing of the Stomach. When we have been long without food, an uneasy sensation is produced in the Stomach which we call hunger. This I suppose to be the Sympathy of the Stomach, with the constitution being in this latter instance a healthy Sympathy, which in the

former instances it was a smothered one. Some would explain hunger in another way; they would say the Gastric juice have nothing to act upon produces uneasy sensations by acting on the Stomach itself. If this was the case, why does it not produce the same effect when the food is in the Stomach? For it is still in that case in contact with the Stomach, though distributed through the food. - Besides it is a law that fluids are never Stimulants to the organ that secretes them, though they may be to any other. The smell of food to a hungry person is pleasing, but to one who has a full Stomach it would almost produce Nausea & this is a Sympathetic Action. - The Mind often powerfully affects the Stomach, the sickness often arising from fear or dread: as an example when we tell that of a Surgical Operation. Hence the Stomach may be said to Sympathize with the Mind as well as the body. Something more may be said of the Stomach Sympathizing with the constitution in producing hunger. - It is a wise provision in nature to make us mindful of supplying the system with nourishment, and much more adapted to preservation, than if it had been entirely left to reason to determine when food is necessary.

There are further reasons for thinking hunger an affair of Sympathy. Animals in a torpid state, take no food. The heart exertions and secretions are nearly quiescent, no exhaustion is therefore produced, & consequently no food

required. In this state if you offer an Animal food that was before agreeable it refuses to eat. The constitution not being in want there is no sympathy in the Stomach, but when the various organs have their actions increased, they devour the same food with avidity. We have a similar instance in People recovered from a fever, when the constitution is left much reduced.

From this cause the patient eats with greater appetite, and frequently every hour, & we find also at such times the Stomach will digest a very large quantity of food.

When the constitution is repaired, the inordinate appetite ceases. Such a diseased state of certain parts as prevents the nourishment from getting into the system produces also a Sympathetic affection of the Stomach, though food be taken in large quantities. Of this kind is a spurious affection of the Pylorus. People under this disease eat very heartily, & yet are always hungry. This hunger often induces them to eat more than they can digest, & part of the food is vomited back.

A stricture in the Oesophagus produces the same effect, but in this case it is difficult to take food into the Stomach.

Another disease producing sympathy in the Stomach, is such a disease of the Lactals as impairs their functions. -- I knew the case of a Lady that was inclined to corpulency till the age of thirty, but afterwards by degrees came extremely emaciated. She eat enormously & sometimes vomited

her food by eating to an excess, & yet she was always hungry. On examination after death, the mesenteric glands were found obstructed and their functions as assimilating organs were greatly impaired. In the exhibition of many Medicines the Stomach may be considered as Sympathizing with the Vascular System. — — — A person in the state of Syncope may be instantly relieved by a Stimulant taken into the Stomach. This must be produced by Sympathy, it takes place too quickly to admit of a Stimulus being first taken into the System. — Another instance of Sympathy in the exhibition of Medicines is, that we can often produce the same effect by throwing a Medicine into the Mass of blood as if it had been taken into the Stomach. Emetics for instance are supposed to act immediately on the Stomach & not by being first taken into the System; yet it is found they will act nearly as soon as if thrown into the Mass of blood. This effect must be produced by sympathy. I injected a solution of two grains of Emetic tartar into the Jugular veins of a dog and vomiting was soon produced. Some might perhaps suppose this took place from the solution being an extraneous body, but injecting the same quantity of warm water, alike effect did not take place. I afterwards repeated these experiments with the solution & similar effects were produced in half an hour.

I wished also to know if the Intestines were not affected in the same way. I therefore infused two grains of Sallop. in hot water and injected the infusion into the Jugular vein as before, and within an hour this dog discharged fluid Feces, and more again in about another hour, but no vomiting was produced.

There are some substances which excite Vomiting & Purging as Gamboge, I dissolved a few grains of this and injected it in a similar manner, & in about an hour purging was produced and soon after vomiting. When Wine was injected it made the dog tipsy. The effects above mentioned we cannot suppose to be produced by Substances being taken into the System and secreted on the surface of the Stomach and Intestines, and we can therefore ~~account~~ account for them no other way than from Sympathy. It has been a question with Physicians whether Bark acted merely on the Stomach or was taken into the System by Absorption. We know that many substances having been taken in the Stomach may be discovered in the Blood & secretion by their smell, taste, & colour. Thus spirits of Turpentine and Asparagus are readily discovered in the Urine by their Smell, and Rhubarb by its colour may be discovered in the blood. Bark being a Vegetable astringent it ought to be easily discovered by a Solution of Iron, provided it enters into the circulation. A good opportunity offered a few

years ago for ascertaining this fact in a Patient of Dr. Keen of
 St. Thomas's Hospital. He had been sometime under a course
 of Bark for an intermittent, and was suddenly attacked with
 a Pneumony which rendered bleeding necessary. On ex-
 amining the Serum of this blood by a Solution of Iron, no
 trace of Vegetable astringency was discovered. The action of the
 Bark on the system being Sympathetic is further proved by
 the circumstance of a large quantity being taken previous to
 the accession of a Paroxysm having a better effect than when
 it is more gradually given. Again it has been enquired
 how Chalybeats acted on the System? I endeavoured
 to ascertain this by experiment. I gave a Dog an ounce of Chaly-
 beat Wine in some Milk. After a time I opened him & made
 two ligatures on the Thoracic duct so as to preserve some
 Chyle pure, I afterwards examined it by adding tincture of
 Gall, but no alteration was produced in it. I gave another Dog
 an ounce of Sol. Martis mixed with his food for several successive
 days. When taking blood and examining it, after this
 time no Iron could be found in it, & therefore none could
 be in the blood. From these experiments it would seem
 that these two important Medicines Bark & Steel
 produce their effects from acting Sympathetically on the
 Stomach, and not from their being taken up into the
 circulating fluid system.

Lecture 9th Chylefaction.

Food is taken in to supply the exhaustion, that is going on in the body, but many changes must be produced in it, before it is fit for the purpose. After being digested the nutritious part is to be formed into Chyle, this again is to become blood, & blood is lastly to form a living solid. When food is digested it is gone a small way towards assimilation, the next change that it undergoes is that of being converted into Chyle, which takes place in the Duodenum &c. When the food enters the Intestines it admits all the characters of digested Matter, and this pulaceous Mass has been called Chyme; but soon after it assumes a white appearance and then it is called Chyle. This Milky fluid is never found in the Stomach. We are now to consider what means are employed to affect this change. It must be brought about by the Duodenum or some fluid connected with it.

We can hardly suppose that the Duodenum can produce any such attraction by any Mechanical power of its own, and therefore it must depend on some fluid contained in itself. It appears that the Duodenum is a secreting organ, just its

being very vascular, and this vascularity being particularly determin-
 ed to the inner surface, and from which we presume the
 secretion is carried on by it. Whenever there is a secretion
 going on we rather expect to find some glandular structure,
 though that is not absolutely necessary. Such structure how-
 ever is found in the small Intestines in great abundance
 more particularly in the Duodenum. One set of glands
 receive their name from Brunner who first discovered and
 described them. They are about the size of a Pin's head and
 situated at the upper part of the Duodenum. The secretion
 from these is more than sufficient to lubricate the Intestine
 and probably therefore it assists in Chylification.

Another set of Glands take the name of Glandulae
 Aggregate from their being situated in Clusters, and others
 again which are more scattered Glandulae Solitariae.
 Besides the fluids secreted from these several Glands
 in the Intestines, there are others poured into it which are
 secreted by large Glands in the Abdomen and whose excretory
 ducts terminate in the Duodenum not far from the lower
 orifice of the Stomach. These are the Liver & Pancreas;
 the Liver secreting Bile and the Pancreas a fluid called the
 Pancreatic Juice. The Pancreas receives blood from several
 sources and hence is very vascular. The ultimate branches of
 the Arteries terminate in Cells, and these again in the excretory

duct that runs along the centre of the gland and as was before said terminate in the Duodenum. The superfluous blood is returned by veins. We shall speak of these fluids as they concern Chylefaction, and first of the Bile. The Bile has been by many supposed to enter into the composition of the Chyle. I am not prepared absolutely to deny this, but am inclined to doubt it, at least it is not so obvious as some have thought. I first entertained doubts of this kind from the following experiment. I opened a Dog and through the Intestine could distinguish the process of Chylefaction going on.

The Bile seemed to flow over the Chyle and not at all to mix with it; for the Chyle adheres so firmly to the sides of the Intestines, that if you want to collect it, you must scrape it off with a knife. Again if the Bile does enter into the composition of Chyle it must either change its properties or loose some of the constituent parts. The colouring parts of the Bile does not mix with the Chyle, otherwise it would give a Yellowness to the Blood, which in a state of health is not found to exist. Bile also is bitter, whereas Chyle is sweet. It may be enquired what purpose the Bile answers? It appears to act as a Stimulus to the Intestines, and thereby assists them in discharging the feces to which it gives colour. In Pueri where the Bile is prevented from entering into the Intestines in its

usual form or rather quantity, the faces are of a light grey colour, and the Bowels are constipated. The Pancreatic Juice is secreted by the Pancreas which lies across the Spine, with one end near the orifice of the Duodenum, and the other on the left side near the Spleen. It is almost nine inches long, two in breadth and one in thickness. This gland is abundantly supplied with blood, chiefly from the Splenic Artery. The ultimate branches of the Arteries terminate in Cells, and these again in small ducts: the ducts therefore are as numerous as their Cells. After their origin two or more unite and form one more visible duct, these again unite and form larger branches which ultimately terminate in the excretory duct. The secreted fluid is found in the Central Canal and the duct terminates in the Duodenum in common with the Ductus communis cholidochus. The manner in which they enter is somewhat peculiar. The two ducts enter the external coat of the Intestine separately forming an acute Angle, & in their passage through the Intestine, they join and enter by one common duct. But there are varieties in this respect, for in some instances both ducts enter an Inch apart, and hence it does not appear necessary that the fluids should be mixed; at least not before they enter the Intestine.

In many animals the ducts are quite separate. The Pancreatic juice is said to have a share in Chylefaction.

This is probable from the change induced on the food being in the Duodenum, and not in the Stomach. (It is not probable that Bile, from the characteristic difference between it and Chyle should mix. And it has been observed that on opening a Dog the Bile appeared to flow over the Chyle, and not to unite with it. If also the Bile entered into the Chyle it would cause a perpetual Jaundice, unless it is proved that in this process it loses all its constituent properties.)

The secretion of the Pancreas was analyzed by a practitioner, he thought it saline, and rather having a tendency to acidity. It has been supposed also to have nearly the properties of Soap, but more recent experiments contradict the opinion. If it be collected and evaporated there are obtained from it crystals, some of cubic and others of a spiculated form. The cubic crystals to the taste resemble common salts, and the spiculated are found to be Sal. Ammon. — Hence the saline matter consists of common and Ammoniacal salts; it is detected by Nitrate of Silver and Muriatic Acid. But how can we collect the Pancreatic Juice? In Dogs the Duodenum is situated rather loosely, not being bound down to the Gland, so that it may be drawn forward, and you may then see where the ducts meet. But admitting there are Mineral Alkali and Muriatic

acid with Ammoniacal salt in the secretions, are they necessary to Chylification? We do not know that they are, and the source of the common salt may be referred to what is daily taken in. The Duodenum being brought forward two Ligatures may be made on the Pancreatic duct so as to include the Juice pure. It cannot be collected after death, for the duct is always then found empty. The Mucous of the Duodenum and Pancreatic Juice, seem to be the principle agents in the process of Chylification; but how they act in producing this change in the food we cannot say: so far we know, it is not long in taking place. This has been proved by keeping an Animal fasting some days, and then giving him food, when in two hours after opening the Abdomen Chyle has been found completely formed. There may be some difference with respect to Herbivorous Animals, the process of Chylification in them being more elaborate. Chyle we know to be that state of food which is necessary to form blood and blood may be considered an Animal substance. It is then very natural to suppose, that there is greater difficulty in converting Vegetable food into Animal matter, than Animal food

which is already formed and analyzed. This difficulty might be obviated by some peculiarity in the assimilating organs of different Animals which we cannot discover. The structure of the small Intestines in Herbivorous Animals would rather agree that Chylification is more laborious in them than Carnivorous ones, they have less Muscularity in the Intestines and a longer canal or else the food would be propelled too rapidly for Chylification. Their capacity is either larger or their internal surface is rendered more extensive. In the Intestines in the human subject are found small projections called Valvulae Conniventes. Some have thought their use to be, to occasion a Remora to their contents, but it seems to be that of affording a greater surface for the Absorption of Chyle. Others have said they were designed to assist the Peristaltic motion of the Intestines: but their situation in different Animals seems to deny this. In the Whale and the Polypus they are longitudinal, in the human circular. Herbivorous Animals have not these Valves, but they have greater length of Canal - Vultures have rough Villous processes resembling a thick fur.

At the inferior part of the Intestines where Chyle is formed, the Valvulae Conniventes are discontinued.

In Animals that live entirely on Animal food we do not find Plaites in the small Intestines, but always something in their stead. In the human subject are small hairlike substances which probably assist in Chylefaction.

Great pains have been taken to ascertain the compound parts of Chyle, but as yet this has not been accurately done. Experiments of this kind are liable to fallacy from the difficulty of collecting the pure Chyle.

From those of Dr. Me. Brides it has been found to consist of Oil, Mucilage, Coagulable matter, & Fixed Air.

It is not certain that these are the parts that enter into the composition of Chyle. If they were by adding them together, Chyle would be produced, but it has been proved that it is impossible to form Chyle in this manner.

Chyle in its colour resembles Milk, and in its properties has been said to resemble it. Milk is found to contain Oil, Sugar, Water, & Lymph, but Chyle has not all these. That they vary much in their properties is further proved from Milk undergoing the same change as the food. It must be digested & coagulated before it becomes Chyle. The Chyle has a Mild bland sweetish taste and seems a Heterogeneous Mass. It is rather white but its colour may be changed, and it is probable that by feeding on Madder this change would be effected.

In many Birds it is naturally transparent like Serum. When Chylification is completed there are two operations set up in the Intestines, one to convey Chyle into the Mass of blood by means of Lacteals, and the other to expel the excrementitious parts which have not been converted into Chyle. This will lead us hereafter to consider the Intestines in a Mechanical point of view.

Lecture 10th

On the Absorption of Chyle.

Having traced the food into the formation of Chyle, we come now to consider the conveyance of Chyle into the Mass of Blood. If we open an Animal a few hours after it has taken food we find adhering to the internal part of the Intestine a white substance as thick as Cream, and which adheres so firmly that it must be scraped off with a knife; this is Chyle. When we have scraped it off we observe a rough surface which had entangled the Chyle, and caused it so firmly to unite.

This surface is called the Villous coat of the Intestines, being composed of a number of hair-like processes or Villi,

like those on Velvet. They are not always equally conspicuous being sometimes flattened. They are easily seen by throwing in a fine injection, and are apparent in the living Animal. In either case they are distended, & they appear organized bodies, having each a blood Vessel, Nerve and Absorbent Pore. The Pore being filled they are kept erect, causing a sensation of roughness. In like manner as by the stimulus of Acids taken into the Stomach, the Papilla of the tongue are kept erect and a sensation of roughness is produced, so probably are the Villi erected by the presence of Chyle their proper Stimulus. Or it produces nearly the same effect on them as the Electric shock does on a Puff. With respect to the Absorption of Chyle, when lying loose on the Villi, there are two opinions, one is that it is performed by Capillary Attraction alone, or that it is combined with other powers, as irritability, and which was the opinion of Haller. Certain it is that the Lacteals whose mouths are the Villi already mentioned, have motion or irritability on the application of the Stimuli.

When a tube having both ends open is immersed in a fluid, that fluid has a tendency to raise in the tube above the level of the surrounding fluid. This can be attributed to nothing but what is called capillary attraction, which takes place universally in an inverse ratio to the size

of the tubes diameter. When the tube is the size of its bore of an Inch the Capillary attraction is scarcely visible.

Many have endeavoured to support their first Theory by applying to it the laws of Capillary attraction. Some of them are that the position of the tube in the fluid is perfectly immaterial, whether perpendicular or oblique, that the attraction diminishes as the size increases in diameter, and that temperature does not affect it. They have further illustrated this opinion by the analogy of Plants, but even in this instance all the laws of Capillary attraction do not hold good. An experiment of Dr. Hales has been brought to support this opinion, that whether a Tree immersed by its roots or its branches, that it regularly receives its supply of Sap; but this does not depend on Capillary attraction, because the circulation of the Sap is regulated by the degrees of heat and cold. In the summer we see the Trees flourishing and full of Sap, in the Winter their leaves fall off and every part seems collapsed probably from the difference of temperature. On the other hand there are some called deciduous trees that are always flourishing, and it appears therefore that the Sap vessels of Vegetables have some attraction of their own independant of capillary attraction. Electricity has also been found to promote the growth of Vegetables, if not too powerfully employed.

Some have endeavoured to compromise the matter by saying the Chyle was carried so far as the first pair of Valves (for all the Lacteals that Absorb have numerous Valves) by Capillary attraction and that then a power inherent in the Vessels propelled it forwards. Baron Haller was of this opinion from the situation of the Lacteals. It has also been supposed that the circulation of the Chyle might be assisted by the neighbouring parts. The Lacteals ramify on the inner coat of the Intestines forming a kind of network & they then pierce through the Intestines. The contraction made on the Lacteals by the Peristaltic motion of the Intestine may facilitate the passage of the Chyle. It may be asked why they would not repel it into the Intestine? Whenever pressure is made on them that have Valves, their contents must be progressive. Some have thought that the Mesenteric Arteries from their contiguity to the Lacteals, might assist in some way by their pulsatory action, but their assistance must be very trifling if any. That the Lacteals are irritable and have a contractile power is evident from experiments. If you open a living Animal when the Lacteals contain Chyle and by pressure upon them or from Vis a tergo, the Chyle will still be forwarded, and if a Stimulus be applied that motion will be increased. If the Absorption of Chyle was performed on the principle of Capillary

attraction, it would continue after death, which certainly is not the case. Farther if it was in any ways affected in that way, in as far would it take place after death, but this does not appear to happen. We must therefore look for some way dependant on life. This appears to be no other than the contraction of the Absorbents, and which appears to be performed more in the manner of a Leech sucking blood more than any other. The presence of Chyle seems to stimulate the Villi to erect themselves and to open their Pores. These by contracting take in a portion of Chyle, which by a similar contraction is propelled.

The mouth or pore then opening contracts again and includes another portion which is forwarded in the same way. After the Chyle has been taken up by the Lacteals, it is conveyed to the Mesentery, the gland of which answers to the Lacteals, as Lymphatic glands do to the other Absorbent vessels. Before a Lacteal enters into a gland it divides into three or four branches which terminate in separate Cells of the gland. On the opposite side of the gland the same number of branches are observed to come out of it, and then to form a single vessel. The branches which enter the gland are called Vasa Affluentia, and their passing out are called Vasa Effluentia. Now what is the use of the glands and what change is induced on

the Chyle in its passing through them? It seems as if they were to effect a perfect Assimilation of the Chyle, for they are Vascular and found to secrete. Their structure is cellular, and not made up of a convolution of Vessels, as may be proved by injection. Probably the Arteries of these glands deposit something which with mixing with the Chyle prepares it for being received into the blood, and makes it more fit for the purposes of life. There are some reasons for such an opinion. Glands are found in great numbers, where there are Lacteals, particularly where these Vessels arise from the small Intestines. They are much less numerous where Lymphatics pass. In Children the Mesenteric glands are in proportions much larger than in Adults, and it is known that they require more nutriment to support their growth. In many old people they are very small. When also these glands are diseased, which not unfrequently happens especially in children, nutrition is ill performed though the appetite is good. This may indeed arise from Mechanical Obstruction, but more probably also from a diseased state of Glands. Mr. Hewson supposed they assisted in forming the red particles of blood, but we find that Turtles have few Mesenteric Glands, and yet a great deal of red blood, and Fishes which have none, have nevertheless red blood.

When the Lacteals have passed through the Glands, they become larger which has given rise to a division into the Vasa Lactea primi generis et secundi. These unite to form larger Vessels, which unite again about the first Lumbar Vertebra and form one large trunk called the Ductus Thoracicus. That part where the Lacteals enter is larger than any other, and is called the Receptaculum Chyli. The Thoracic duct passes on the left side of the Spine, between the Vena Azygos and Aorta, and is continued under the Aorta at its curvature to the lower part of the Neck, where it takes a turn downwards and enters the left subclavian vein, at its juncture with the internal Jugular. When we consider the great number of Lymphatics and compare their proportional bulk with that of the Thoracic duct it seems hardly possible that all the fluid they take up should be conveyed by it. This has led some to suppose that there must be some other way for the termination of Lymphatics into red Vessels besides that of the Thoracic duct such a way however cannot be found. I have indeed found that the Absorbents of the Heart, pass at once into red veins without going through the course of the Thoracic duct, and I have seen the same with respect to the Stomach; but these are not sufficient facts on which

to build any expectation of consequence. The proportionate smallness of the duct may in a great measure be accounted for, from absorption not going on in every part of the body at the same time. Those who suppose that the Thoracic duct is not the only way from the Lymphatics into the blood, make this further objection, that sometimes the duct is obliterated in one part without producing emaciation. Dr. Cheston met with a case of this kind, but when such obstructions are met with, it is also found that there is a communication between the upper and lower part of the duct by means of collateral branches.

If any obstruction could be found near the entrance of the duct into the Subclavian vein, it would give a great probability to such an opinion.

I endeavoured to imitate such an obstruction, by making a ligature on the Thoracic duct of a dog, and the Animal did not die for want of nourishment. Dr. Munro however could never make the experiment without killing the dog, & hence in this case I cannot draw a satisfactory conclusion. And although I cannot speak confidently in this instance, I can do so as to the termination of the Absorbents into red veins as before mentioned. This last fact may perhaps explain the

speedy increase of Urine, so soon after fluid taken into the Stomach, from its getting by red veins into the circulation, and so be conveyed in a more direct manner to the Kidney (whose office it is to secrete Urine from the blood) than if this same fluid had undergone the process and course of Chylification.

Lecture 11th

Peristaltic motion of the Intestines.

We find the same connections between the Chylifying and Muscular powers of the Intestines, as between the Digesting and Muscular ones of the Stomach.

Carnivorous Animals assimilate their food quicker than Herbivorous ones, and have stronger Muscular fibres in their Intestines and they possess greater.

Hence in these, excrementitious matter is soonest expelled, while in the Herbivorous the circulation is slower through the Intestines and more time is allowed for Chylification. The action of the Intestines in expelling the feculent Matter is called the Peristaltic Motion. This is difficult to describe to those who have never seen it,

but it is not unlike the motion of a worm. It consists in shortening and contracting of the Intestines, which begins at one part and is progressive, and then begins at the same part it before terminated and in this way extends through the whole. We can have no Idea of the gravity of the feculent Matter assisting the Intestines in their expulsion, the contraction of the Intestines being so numerous. The structure of the Intestines confirms the Idea that they have two motions, their being fibres in a longitudinal and circular direction of which the latter are the stronger. When the longitudinal fibres over act the circular it causes an intussusception. The Intestines are extremely irritable and their functions seem to go on longer than those of any other part. Though their irritability is very great, yet it is probable that they have but few Nerves, this not being necessary from the Will having so little power over them. Some have deny'd their having any Nerves, but this is untrue. If you kill an Animal and immediately open the Abdomen, the Peristaltic Motion will be clearly seen. The irritability of the Intestines may be greatly diminished by cold. In making an experiment on the Spleen of a Dog, I observed that a part of the Intestine had escaped from the Abdomen and the

Peristaltic motion had entirely ceased from the exposure to cold. Heat on the contrary will restore the motion.

Opium also diminishes the irritability of the Intestines, as likewise astringent Medicines. The irritability may be increased as before said by heat, and by the presence of food, flatulency, or elastic Matter &c - - -

All these stimulate the Intestines, hence a moderate degree of flatus in the Intestines may be useful or rather necessary, but if there is too much griping produced by the Intestines being stimulated by over distention and too violent contraction. Bile is the natural Cathartic. In Jaundice there is a deficiency in this, hence Costiveness and white Stools; and again when this follows there is a Liarchoa. Nastic Purges act by determining a quantity of fluid to the surface of the Intestines by stimulating the gland and thus increasing their secretion, and in consequence the Peristaltic motion is increased. It was mentioned in a former Lecture, that the action of the Intestines might also be promoted by Sympathy. In some Animals the Peristaltic motion is very languid, and hence they are very difficult to be purged. It may in part arise from the thinness of the Muscular fibres and partly from the length of the Intestinal Canal. There is a difference in human

subjects with respect to the torpidity of the Intestines.
 (Some causes have a tendency to diminish the Motion,
 amongst these are Opium and astringent Medicines.)
 Injuries and compression of the Spinal Marrow,
 may interrupt the functions of the Intestinal Canal
 when they happen low down. The Sympathetic Nerve
 principally supplies the Intestines, and the lower
 down the Spine the injury is done, the more likely
 this nerve is to be affected, and hence the disease
 will take place more or less according to the situation
 upon which the injury is received, and thus confirms
 the existence of Nerves in these parts. The retaining
 power of the Intestines may be diminished from the Sphi-
 ncter Ani losing its elasticity, for after death the
 stretch of the Sphincter returns to its original di-
 mensions, and hence its action is different to muscular
 motion. Mechanical pressure as in the Strangulated
 Hernia, may produce an inverted peristaltic Motion, &
 the same effect succeeds to inflammation arising from other
 causes. This is manifested by vomiting and that often of the
 contents of the Intestines, the matter brought up having
 a stercoraceous smell and appearance. It has been often
 said that the contents of the Intestines were vomited in a
 Strangulated Hernia, but they are not with propriety called feces,

untill they have entered the large Intestines, and it will be presently shewn that the contents of these cannot regurgitate into the small ones. An inverted peristaltic motion with its consequences may also be produced by Mal-conformation. I have seen a small Intestine terminate in a blunt end, there being a space between the end of one Intestine and the beginning of another.

When Bile is vomited it is brought up by an inverted peristaltic Motion of the Duodenum.

When the remains of the food are passed through the small Intestines in which it may be said that all the Nutrient principle is extracted, they are propelled into the large one and are there called feces.

At the end of the small Intestine where it enters into a large one, is a Valve so constructed as to prevent the feces from regurgitating. It has been a question and is still of no small importance to be determined, how far nutrient substances thrown into the large Intestines would nourish the Machine? Absorbents arise in great abundance in large Intestines, but what is taken up by them, cannot have gone through any Assimilating process. I am therefore of opinion that life may be protracted for a while; but the Nutrient Matter not having been assimilated the Patient must at length die from exhaustion.

if neither medicine or nourishment can be taken into the Stomach. When the feces have passed through the large Intestines they must necessarily be discharged.

As members of society it is more convenient that this should be done at particular times, and to retain the feces therefore untill a convenient time occurs for discharging them. There are at the extremity of the Rectum a number of strong Muscular fibres, forming the Sphincter Ani. These may be said to have three powers, viz, Elastic, Contractile and Tonic. It is by its Tonic power that the Sphincter Ani retains the feces in common without any exertion.

When the Muscles that assist in expulsion of the feces, as those of the Abdomen and Rectum above the Sphincter overcome the Tonic and contractile power, and thereby causes a discharge of them, its Elastic power is then necessary by which it is brought back to the former state. — — —

In Horses the Rectum is inverted in discharging the feces, but it is immediately drawn up afterwards.

This is not the case in Man if the parts are in a healthy state.

Lecture 12th Of the Spleen.

We have finished what was to be said on digestion and

Chylefaction, but after the food has been digested there is generally some space intervening, before more food is again taken into the Stomach. During this time it is natural to suppose that the Gastric secretion is less plentiful than when food is taken into the Stomach. It is a law in the Animal Economy, that organs secrete in proportion to the quantity of blood sent to them.

We are now to enquire how far the Spleen assists in determining blood to the Stomach during digestion and thereby promotes its secretion. The Spleen is an oblong body six Inches in length, three or four in breadth, and one or two in thickness. It is situated near the Stomach.

It differs in shape in different Animals. It is of an irregular form in Dogs, flat and thin in Calves, and Globular in Birds, hence whatever be its use it cannot depend on its figure. The size also is various.

I have known one to weigh an ounce, while others weigh a pound or more, and this without any difference in structure or any appearance of disease. The general weight however is about eight ounces. Its colour in infancy is lighter than in the adult age, and which arises from the difference in the balance of circulation, between the Arterial and Venous blood there being more of the former in young children. The Spleen is not

perfectly oblong, but rather of an oval figure, having one of its sides convex and the other concave. It is situated in the Hypochondriac region. The convex surface is turned towards the Diaphragm and confined there by the reflection of the Peritoneum, while its concave part is resting on the left extremity of the Stomach; hence the Stomach always presses in some degree against the Spleen, but must do so in a much greater degree when the Stomach is full.

The Spleen is very vascular being supplied by a branch of the Celiac called the Splenic. The Celiac is a short trunk arising from the Aorta soon after it enters the Abdomen. It then divides into three branches, the Hepatic, Splenic and Coronary. Before the Splenic Artery arrives at the Spleen, it gives off several branches; some to the Pancreas and others to the Stomach. Those going to the Stomach are, one large, distributed to the right extremity called Gastrica dextra, and greater curvature of the Stomach, and several small ones called vasa brevia which ramify on the left extremity of it. Before the Splenic Artery enters the Spleen, it divides into a number of branches, they are large in proportion to the size of the Spleen. If you inject by the Arteries they terminate too minutely in cells for the injection to pass, but if the same is done by the Veins, the injection appears to be one mass having a granulated

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appearance on the surface and retaining the shape of the Spleen. The Spleen is at all times tender and if great care is not taken the Veins will be ruptured, but this grammate appearance when it is injected in the most careful manner, is very different from the confused mass which is caused by a rupture of Vessels. How is it that the Cells of the Spleen are completely filled by the Veins and not by the Arteries? These ramifications of the Arteries as before hinted are so minute before they enter the Cells that the coarse injection used for corroded preparations cannot pass through them; but the orifices of the Veins arising from the Cells are so large that even a common injection will pervade them.

The Cells however may be filled by the Arteries by a common fine injection. No one doubts the Spleen being cellular, but the way many Anatomists have taken to prove this has in general been very unsatisfactory.

They have after working the blood out of it, distended it with Air and then made sections out of it. Now almost any part in this way may be made to appear cellular.

The most satisfactory manner is to inject carefully, and afterwards to destroy the substance of the Spleen by corrosion. The more clearly to prove the cellular substance of the Spleen, I had recourse to the following experiment.

I made a small opening into the Abdomen of a Dog so as to let the Spleen hang out. Having done this I easily distinguished the Artery and Vein from their colour. I made a Ligature on the Vein, and the Spleen was almost immediately increased to three times its usual size. Had this distension taken place merely from an enlargement of the blood vessels, it must have been in a more gradual manner. The vein which returns the blood from the Splenic empties itself into the Vena Portarum which is carrying blood into the Liver for the secretion of Bile, and hence the blood conveyed by the Splenic Vein must have some share in the formation of Bile. The Spleen is supplied by numerous Absorbents, but they are not so evident in the human subject as in some other Animals.

A proportionate quantity of Nerves also, are distributed to the Spleen, and those intervening round the Splenic Artery are called the Splenic Plexus. Here then are all the parts constituting a gland, except its excretory duct which has not been found. (Having premised so much with respect to the figure and structure) we come now more particularly to the consideration of its use.

We see it supplied with a quantity of blood, equal to that of any gland of the same size, but did it perform the office of secretion it must have an excretory duct. Anatomists

have puzzled themselves very much to find out an excretory duct, but have not been able to succeed. The use of this organ has given rise to various opinions, and some have been so absurd as to suppose it had no use at all.

Others say it is to supply the liver with blood and so it does. But it is highly probable that it has something else to do, some other function of a more important nature, for though it is only one fourth of the size of the Liver its Artery is larger. Some opinions of the use of the Spleen are so improbable and even ridiculous that we shall barely mention them. It has been said by some to be a balance for the Liver, by others the seat of laughter, and others say again it is the seat of Melancholy.

The Ancients thought there were two secretions of Bile and that one of these was performed by the Spleen, the *Atra-Bilis*: These Ideas are too wild to require a refutation; But the moderns have delivered opinions on the use of this organ, and these require our attention.

Among these, is that of Mr. Hewson's. He had particularly turned his attention to the red particles of blood which he examined very accurately with a Microscope. He found that their shape was nearly flat & circular, and that the edges have the appearance of a Vesicle. From the particular structure of the red particles, he conceived

there must be some organ for making them, and he wished to make those organs whose functions are not understood subservient to this purpose. He says accordingly that the central part of the red particles is formed by the Thyamus Gland & the Vesicular by the Spleen. To prove that the Spleen performed this office he examined blood going to it and some that had passed through the Spleen, and he found that before it had entered, the red particles had only this central part, but after they had passed through it they were complete.

I examined the blood under these circumstances but could not find any difference. Mr. Hewson further explained his Hypothesis by substituting another, and he said that the blood in its passage through the Spleen, lost its coagulable part, & that it goes to form the vascular part of the red particles.

Baron Haller and professor Mitchel, say that the Venous blood of the Spleen does not coagulate; and it is not improbable that Mr. Hewson took this opinion from Baron Haller and never himself tried the experiment. I collected an ounce of Splenic venous blood and I found it presently to coagulate as if taken from the Arm; Mr. Hewson's opinion therefore falls to the ground. Another Physiologist (Dr. Munro) has investigated this opinion of Mr. Hewson and endeavoured to refute it. He observed that the size of the Spleen is not in proportion to the quantity of red blood found in some Animals, and yet

they have very few red particles of blood. But what he principally supposed that he refuted Mr. Hewson in, was, in discovering the cells in which the red particles were supposed to be completely formed; The large cells of the Spleen were found less than Mr. Hewson described the red particles to be, and it is evident that he never made use of a less Magnifying Microscope than Mr. Hewson did.

The present general opinion of the use of the Spleen is that it is subservient to the Liver in the secretion of Bile.

Baron Haller says very truly that the Blood circulating through the Spleen goes to the Vena Portarum, and from thence to the Liver. But blood which is circulating through the Stomach, Omentum, Pancreas, &c. does the same.

And do we say that these viscera are only auxiliaries to the Liver? Certainly not. Why then should it be said of the Spleen particularly, that its use is to assist in the formation of Bile? Some say that the blood in its passage through the Spleen undergoes a change to fit it for the secretion of Bile. We are told of the several attractions of this kind. Baron Haller indeed says that it is Alkalescent.

It is an Idea that Bile is a putrescent fluid, and that Alkalescents are very susceptible of putridity. Neither of these Ideas however appear to be facts. I took blood from the Splenic vein and after the Serum had separated

tried it with turmeric paper, which discovers the least degree of Alkalescence, but none was found. If Bile and Blood are separately exposed to the Air, the Blood will first become putrid. Again it has been said that the blood circulated so slowly through the Spleen as to be rendered putrescent.

I took blood from the Splenic and Jugular veins and placed them in a temperature of fifty degrees for a day, but no alteration took place. The next day I placed them in the temperature of ninety, but still they were little altered. On the third day putrefaction was observable but in both alike.

It seems then that during two days no putrefaction took place, and further the blood is not above two minutes in circulating through the Spleen, nor ever under half a minute.

I proved this by tying a vein and then puncturing it, & observed after the vessel had regained its usual size, for it would be enlarged by tying the vein, (before the puncture was made) how much blood flowed in a given time.

Others have said that the Splenic blood is more fluid, and is therefore more fitted for discharging the Bile which is expressed as being Acid. But how is the blood thus rendered more fluid? Does the Spleen take from it, its coagulable part, or does it add more serosity to bring about its dilution.

Besides it is clear in fact that this great fluidity does not exist. To ascertain this I took away some blood that had

entered the Spleen and some that had not passed through it. On examining the Serum of each with its Crassamentum, I found the comparative proportion of each nearly the same, as existed in the blood drawn from any other organ.

In the Arterial blood the Serum in weight was to the Crassamentum as 455 to 1000. This trifling difference cannot be regarded as any thing more than accidental.

I also examined the blood that had passed through the Spleen by Chemical tests, and compared it with blood taken from other parts but found no difference.

From these experiments I do not hesitate to say that the Splenic blood has not any particular properties which can assist the secretion of the Liver, nor has it any particular in diluting it. But then supposing the Spleen is necessary to the secretion of the Liver, ought not that secretion, if the Spleen be removed, to be different; and yet from experiments and Chemical tests, it is not found to be so. I took out the Spleen of a Hog; at first he appeared emaciated, but soon after took his food tolerably well, and seemed to be nourished as well as formerly.

In about two months time I strangled him and another hog at the same time whose spleen had not been removed. Bile was taken from both these Hogs and carefully examined, but the examination did not

prove any difference. The more accurately to conduct the Chemical part of the experiment, I procured the assistance of Doctor Babington, whose skill in this science needs no comment of mine. Hence the Spleen does not appear necessary to Biliary secretion. But some say that although the properties of the Bile are not altered by the Spleen yet the quantity is. Mr. Coleman took the Spleen from a dog, & he found that he was costive for several days, and this was supposed to prove that the secretion of Bile was diminished. I tried the same experiment and the dog had a Diarrhoea, so that the costiveness in the former case seems to be accidental.

At the Battle of Lettingen a Soldier had been wounded in his side. He lay during a night on the ground, & when discovered by the Surgeon in the morning, the Spleen was found hanging out of the Abdomen. It was so much enlarged that the Surgeon thought proper not to return it, & therefore removed it, and no inconvenience was afterwards found from the loss of it in the Animal functions; hence Mr. Cline considers it to be an Organ of convenience more than necessity. Many of those who think that Bile assists the progress of Chylefaction, thinks that the Spleen assists in the following manner. When the Stomach is distended it presses on the Spleen and accelerates the circulation through it, and more blood being sent in this

way to the Liver, more Bile is in consequence secreted. Haller
 was of this opinion, but from experiments, I found the contrary
 to be the fact. It is necessary to see what effect the pressure of
 the Stomach can have on the Spleen. while in the Body, but I
 endeavoured to imitate it out of the Body. For this purpose
 I made an opening into the cavity of the Abdomen of
 a Dog, so as to let out the Spleen; I then made a ligature on
 the vein, I punctured it between the ligature and the Spleen,
 this being done I pressed the Spleen in different degrees
 between my fingers and invariably found that a circulation
 was impeded after the first gust occasioned by the
 ligature was over. The fact then in which this opinion
 was founded, seems to have no foundation, for pressure
 we see retards the circulation. From the knowledge of the
 fact just related. I was led to theorize and the conclusion
 I would draw is as follows. It is clear that if the blood
 does not flow with freedom through the Spleen when
 pressed upon by the Stomach, it must pass in greater
 quantities by the Arteries given off before it enters that organ,
 that is to the Stomach and Pancreas. It is equally clear that
 the Stomach when distended must make more or less
 pressure on the Spleen; and that after the food is digested,
 the Stomach being less distended, the pressure will also de-
 crease. When the Stomach is ~~not~~ distended with food

there is occasion for the gastric Juice. Now it was before shewn that pressure on the Spleen by impeding the circulation of the blood through it, would necessarily determine more to the Stomach, and consequently by its secretion would be increased. When also the Spleen has been removed, the Arteries passing from it to the Stomach and Pancreas have been found to become less. It was before observed that a dog whose spleen had been taken out, became emaciated although well fed.

But whether this arose from imperfect assimilation I do not know. In another dog a similar experiment was made and the emaciation continued only a short time. (From what has been said I am inclined to think the use of the Spleen is to assist in Digestion by determining more blood to the Stomach when distended with food and thereby increasing its secretion.) I do not offer my Ideas of the Spleen being thus far an auxiliary organ to digestion, as a Theory not exposed to objections, but it appears to me more probable than any other I am acquainted with. If this theory be founded on facts, there must be certain things which take place in all Animals, namely, that when the Stomach is distended that it should press upon the Spleen, and that the Spleen is compressible; and in consequence more blood

is determined to the Stomach. I have made experiments to investigate this, and as far as I have examined have found them to coincide, but at present I have not sufficient facts to adduce in support of them. It yet remains therefore to be enquired into whether in all Animals the Spleen is situated so as to be compressed by the Stomach, whether the Vessels of the Spleen and Stomach ramify in the way already mentioned, and whether the structure of it in all Animals be such as to favour these circumstances. This will lead to an extensive enquiry, and will confirm or weaken my opinion.

Perhaps the use of the Spleen will never be well marked, for as Animals live very well with or without it, it seems rather an organ of convenience than necessity.

Lecture 13th

On the Economy and Properties of the Blood.

By the Blood we mean that fluid circulating through the Arteries and Veins, and propelled by the Heart.

In Man, Quadrupeds &c, we know it is of a red colour, and hence are we to consider this colour as essential to Blood. The blood in Lobsters is colour less, like water, and

many Insects as Caterpillars have colourless Blood, while others have blood which is green. When Blood is drawn from the body it appears an homogenous mass, but soon after it loses its fluidity, and coagulates, and from this coagulum effuses water.

Thus the blood divides into two parts, the solid part called Crassamentum, and the fluid called Serum. But are there not other parts in the Blood? If you expose the fluid it coagulates, and from this you may squeeze water, which by a great Physiologist was called Lerosity. In the same manner the Crassamentum may be separated into two parts, one of which is whitish and solid, and the other red, the former being separated from the latter by abluition. Hence then there are four parts composing the Blood. Other substances as neutral Salts are occasionally found in the Blood; but we do not consider these as constituent and grand parts. In different People these four parts of the blood differ much in their proportion and even in the same person at different times. In a strong man there is great solidity; in a weak man there is more water, and even in the Crassamentum there is a lower texture. In females labouring under Chlorosis there is a very small portion of red particles and when E. S. was performed so white was the blood that it gave no colour to a white body immersed in it. After making these general observations on the Blood, as composed of different parts we will now consider

it in the aggregate. And first what is the relative quantity of Blood in the system? Various have been the opinions on this subject. It would seem easy to ascertain this by bleeding an Animal to death, and then weighing the blood, and the Animal afterwards; but this is not accurate, for Animals die before all their blood is lost, and a great deal depends also on the manner in which the blood is taken away; great quantities have been lost in a gradual manner by natural Hemorrhagy without endangering life; but if we take a small quantity from the Aorta or other large vessels, the Animal will die in a short time.

'A Man had an Aneurism which suddenly burst, one pound of blood was lost and he presently died, & yet we take several pounds from other parts without danger; hence taking blood from living Animals will not lead us to a relative knowledge of its quantity in the system.

Indeed the difference in result of experiments of this kind fully proves this; for while some have told us that the blood is in proportion of one to ten, others say it was only the proportion of one to twenty. While circulating through the body the blood is fluid, but if from the rupture of a Vessel it be extravasated it soon loses its fluidity while yet in the Vessels, as in the case in Aneurism and this change takes place in consequence of its being nearly in a state

of rest. In these Tumours the blood may circulate thro^o the direct line of the vessel, but on the side where the Sac expands it becomes collected. It seems therefore that rest favours the coagulation of blood. This is an important fact respecting the art of Surgery, and we may often avail ourselves of it in assisting Nature in the stoppage of Hemorrhage. It is by a contraction of the mouth of the Vessel. W. Bayⁿ Bell says, and it is natural enough to suppose it; but from experiment I am convinced that it is stopped by a consolidation of the blood itself.

I opened the Crural Artery of a Dog. It bled for a short time and then ceased, forming a small tumour.

On examination I found the coagulation of the blood extended to the extremity of the Vessel and plugged it up, but the mouth of the vessel was not at all contracted.

The resources of nature in a Dog are superior to what they are in the human subject, as the latter would have died under the experiment. The Surgeon assists nature in the stoppage of Hemorrhage either by ligature or styptic.

Supposing a ligature to be made on a bleeding vessel, in a few days it is removed no bleeding follows it. What is the cause of this? It is from the pressure of the sides of the Artery against each other produced by the ligature.

The Ligature obliterates the cavity of the vessel as long

as it is applied, but after a certain time it ulcerates through it, and sometimes bleeding follows. If we examine an artery after it has been thus tied, we find that nature acts in the same way, as when no ligature is made, we find a coagulation of blood just above the ligature, formed in the same manner as in the femoral artery of the dog. Now it seems the ligature prevented the blood from flowing at first, and thus keeping it in a state of rest favoured the coagulation which naturally plugged up the vessel. Hence it appears that a ligature may be removed without danger, after a certain time has been allowed for a coagulation to take place. It sometimes happens that an Hemorrhage does take place on removing the Ligature. Now from what cause does this take place? Is it from the imperfect tying of the vessel or from the new coagulation of the blood? It is probable that the Ligature may have been made too tight, so as to cut through the vessel, or at least to induce a very speedy ulceration of it. This suggests to us the propriety of making ligatures with caution and using such as are broad and flat, and not so apt on that account to cut or ulcerate through the vessel readily. The coagulum sometime after adheres to the vessel and even becomes organized, so as to be capable of being injected. From what has been said it seems that a state of quiescence is most favorable

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to the coagulation of Blood, and on the other hand, a state of motion and action tends most to preserve its fluidity.

A very little motion seems sufficient to preserve the fluidity of the blood, as we see from the circulation being kept up in torpid animals. We ought for the same reason to be cautious in the choice of the part of the vessel on which we make Ligatures, as we cannot with propriety make a Ligature on the Vessel at or immediately below a part where another Vessel is given off. Supposing there was an Abscess situated high on the thigh and a Ligature was made on the Femoral Artery just where it gives off the Arteria Profunda, the Vessel being ulcerated, an Hemorrhage would ensue and the Patient loose his life. Sometime since a Patient was admitted into a Hospital in town labouring under a Bronchocele, the Surgeon under whose care he was, thought that if he could intercept the blood going into the Tumour, he could cure the disease. He dissected through the Sternocleidomastoid Muscle, and made a Ligature on the Superior Cerebral Artery, which is going to the Thyroid Gland. He applied the Ligature near where it is given off by the external Carotid, and intended that if this had succeeded to have proceeded in the same way on the other side.

The blood however constantly flowing through the Cord kept the blood in the space between it and the Ligature in motion

and thereby prevented the formation of coagulum where the ligature was made. An ulceration taking place in the Vessel an Hemorrhage came on and the Patient died. It happens often in scorbutic habits that though the vessels be tied with the greatest care an Hemorrhage will ensue at the usual distance of time from the operation. This depends on the debilitated state of the constitution. If a ligature does not ulcerate from ten to twelve days after an operation we may safely pronounce that the Surgeon has done his duty; but if an Hemorrhage was to take place in a day or two after we may conclude that the ligature was improperly made. In a Scrophulous habit, if the Hemorrhage ceases, we may perhaps obviate its return by Nutrient diet, Bark &c which gives to the blood a disposition to solidity. But what are the powers and resources of Nature here? More credit has been given to Styptics than in my opinion they deserve; and we should endeavour to know the power of each in this respect; we have always seen the resources of Nature in checking Hemorrhage; but we do not know so well the power and operation of Styptics.

Lecture 14th The Blood continued.

We before considered the blood as to its quantity & the great difficulty in determining the point. We then took notice of its constituent parts, and the Homogeneous appearance it first assumed, as well as the spontaneous separation which took place afterwards. We spoke of the stoppage of Haemorrhage as brought about, not by the contraction of the Vessels, but the coagulation of blood at the mouth of it. We then next considered what most contributed to this consolidation and particularly noticed rest. But there are other circumstances respecting this subject which we are next to consider. Mr. Hewson made many experiments to ascertain whether a transition from heat to cold, did not promote the coagulation of blood. He laid bare the Jugular vein of a Rabbit, and made a double ligature on it. He then took out of it a part containing blood, and put it into a freezing Mixture. When taken out of the Mixture he found it was congealed, but after having thawed it in warm water, it became again fluid, and on exposure to air coagulated.

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From this he was lead to suppose that the Air and not the cold alone coagulated blood. He also took blood away in two cups, one of which he put into warm water at the temperature of ninety five, and the other he exposed to the Atmosphere at the temperature of fifty six.

The cup that had been put into the water had its blood first coagulated, and hence he thought that cold had no power in producing this effect. He also laid bare the Jugular vein of a Rabbit and made three ligatures on it at an Inch distance from each other, he then punctured one of the portions of the Vein between the Ligature and introduced Air, after which he untied the middle ligature, so that the Air might come in contact with the blood contained between the other ligatures, and he said in a short time the blood coagulated. I also laid bare the Jugular Vein of a Dog, and introducing Air found it to lie on the surface and not to mix with the blood, but in half an hour the blood was as fluid as at first. Hence the conclusion that I draw is different from Mr. Hewson's. I know besides that Air will not mix with blood if in circulation nor produce coagulation of it. Mr. Hewson observed blood at one time to coagulate very soon, and at another not so readily; and he remarked that the weaker the Animal was the sooner the coagulation took place. This if it be true is of

importance in Surgery, as it would lead us in case of Hemorrhage to favour and even to promote Syncope. But Mr. Hay has made some experiments which seem to contradict Mr. Hewson's. He attended the slaughter of sheep & caught blood in three different vessels. In the first he received some blood immediately after the knife had been plunged into the throat of them. In the second a little time after; & in the third, just as the animal was expiring; He found the blood in the first cup coagulate soonest, when the Arterial action was strongest and that it separated the largest proportion of Serum; and exactly the contrary took place, with respect to the blood in the last cup.

Hence Mr. Hay's experiments contradict Mr. Hewson's. I have not yet repeated these experiments myself, therefore cannot determine which is right. In repeating these experiments on Sheep. I found the Animal die so soon that the blood had not time to undergo any material change, and that the better way would be to take one ounce of blood from the Jugular vein of an Animal when in health, and suffering it to flow, take more half an hour afterwards, and a third quantity at a still greater distance of time, and then observe the respective periods at which each quantity would coagulate. — Under inflammation the blood is subject to great

changes, it becomes more fluid and assumes a buffy appearance from the red particles falling to the bottom in consequence of its slow coagulation. Mr. Hewson endeavoured to explain the cause of this fluidity in blood; he thought the blood was attenuated or diluted, that is, its possessing more water. To ascertain this Mr. Hov made experiments on inflamed blood and he found more water to separate from buff blood, than any other, and hence supposed it was diluted and not attenuated. The change taking place in blood while circulating through inflamed vessels deserves notice.

Sometimes this change is slow and gradual, at others sudden. Let us suppose the Pericardium the seat of inflammation, if this at first is mild it increases the *Liquor Pericardii* which is secreted from the extreme vessels, but if it goes on more violently we find a large thick crust instead of this increased secretion. Hence we may say that mild inflammation poured out water, and that greater gave coagulable Lymph. Sometimes adhesion takes place from the great inflammation throwing out its Lymph which afterwards becomes vascular, and thereby adheres to parts, this takes place in many parts as the *Tunica Vaginalis Testis* after the operation of *Hydrocele* &c.

The *Tonica Decidua* which covers the *Ovum* & attaches it to the *Uterus* appears to be nothing more than coagulation of *Lymph* thrown out by the *Arteries* of the *Uterus*.

But the *Lungs* are most commonly the seat of this adhesion, which may be either partial or general and confined to one, or extending to both *Lungs*. The older the adhesions the more extensive they become and the less inconvenience with respect to motion is experienced from them, and they often assume the appearance of common membrane. We find this *Lymph* in time becomes as vascular as other parts, from the action of the vessels of the neighbouring parts the vessels becoming lengthened and causing them of thus shooting through the *Lymph*. This organization of the *Lymph* takes place in a longer or shorter time according to the extent of the vascular surfaces in contact with each other, and hence it must take place in a short time in adhesions of the *Lungs* to the *Pleura*.

I have known coagulable *lymph* in this part organized in twenty four hours, as was proved by injecting it. In the coagulable *lymph* which plugs up *Arteries* in the stoppage of *Hæmorrhage*, the process of vascularity is more slowly performed probably from the extent of vascular surface lying in contact with the blood being greater from each other.

Some say the consolidation of *lymph* is slow, others say it is rapid; I think the latter opinion is the true one. ---

If a vein be tied or exposed in that state it will inflame & the Vasa Vasorum throw out lymph; if the lymph was fluid it would be carried along with the circulating blood, but its being found in arteries and veins would lead us to suppose it consolidates as soon as it is effused. Mr. Hunter had particular opinions on the subject of the blood, more particularly as regarding its life. Harvey from his enquiries into generation first started this opinion of the life of the blood, he said he saw blood before he saw vessels, and that it must exist of necessity before vessels could be formed.

Mr. Hunter considered this at length, but the principle of its becoming a solid from a fluid, its life, though at first he considered this change to be produced by what he called the stimulus of death. Mr. Hunter thought the life of the blood favored its coagulation, and that the union of living parts by blood was one proof of its life. It was said to become vascular here, whereas if it was an inanimate substance it would not. But different opinions are held on the subject of the vascularity of the blood. It may it is said have a centre of ramification, though Mr. Hunter once thought there was no proof of this or it may become vascular by lying near vascular parts, the vessels being formed stratum super stratum. But it is probably a passive medium only for vessels to shoot through.

Another reason for the life of the blood was its disposition

to solidity on exposure; but we might as well say, that saline matter was alive because it crystallized. Again it was said to carry life to every part of the body, and if its course was interrupted the part dies, but there is the same reason for food to be alive; not knowing the essence of life we cannot speak with certainty of it in this instance, though the blood it is probable has something different in it from inanimate matter. The blood being found fluid after death, depended according to his Theory on the mode in which death took place. If it was sudden there was not time for it to coagulate and hence it retained its fluidity. A blow on the Stomach causing sudden death occasioned the blood to be fluid. Mr. Hunter also found it fluid in two dead, hence he considered the solids died first and then the fluids.

To ascertain whether this was the fact, I struck down a Rat by passing an Electric shock through its head (by means of a large Battery.) I then opened the cavity of the Abdomen & I found the inferior Cava to contain coagulated blood. I repeated the experiment on a large scale & with the same result.

Hence it appears that Mr. Hunters opinion on that subject was not accurate. Now we know that executed subjects have fluid blood, their death is much slower than that of Rats alluded to, and yet the blood in them is more fluid.

The blood supplies nourishment & repairs injuries

of the Machine. If a part be divided & again brought together, it unites and becomes vascular, through the medium of the blood, and if not brought together immediately but at some distance of time from the injury having been received, it will unite if coagulable lymph be thrown out by the inflammation which ensues. This is called union by the first intention.

And it may be said to be brought about by two modes; first by the medium of the blood itself, and secondly, by the coagulable lymph; but there is a third mode, which is Granulation. This is formed by coagulable lymph being thrown out and becoming vascular. When a Bone also is broken, the vessels are torn, they inflame and throw out lymph first and afterwards a callous or bony matter is deposited.

Nerves and Tendons when divided unite in the same way, hence parts have the power of assimilating blood to their own substance, something like secretion. Dr. Cullen thought the Nerves secreted a nutrient principle by which parts are renovated; and Dr. Munro thought that union was produced by means of Arteries and blood. Parts have life and strength in proportion to the quantity of blood circulating in them, and this power of repairing injuries is in proportion to the vigour of the circulation. I proved this by the following experiment; I divided the tendo Achillis in both legs of a Dog, in one of which the Femoral.

Artery had been previously divided. In that limb in which the circulation was free, and which was well supplied with blood; the Chasm made by the division of the Tendon was filled up in about a fortnight with a substance which afterwards became Tendinous. In the other limb the Chasm was at first equally large, and at the end of six weeks the Tendon of it had not united. I killed the Dog at this time and examined both legs. In that where the circulation was uninterrupted I found the Tendon completely formed, but in the Leg where the Artery has been divided, there was only a very small string, which with difficulty could be preserved in the dissection.

From this experiment we see that blood repairs injuries, and that it may be present in a part, in sufficient quantity to support life, though not to form new parts, for in the latter case the limb was preserved though the Tendon did not firmly unite. In a patient of Mr. Cline's who had Popliteal Aneurism, the Artery was taken up, and at the same time she had an Ulcer on the Leg, (as long as she lived which was several weeks) it shewed no disposition to heal. This could not be impeded by any general weakness of the constitution, for the Granulations in the wound made by the operation, healed very well. It could therefore be only owing to the interruption

of the circulation caused by the Ligature above.

Parts have vital power we have said, in proportion to the quantity of blood circulating through them and thus an injury done to a muscle is sooner repaired, than one done to the Skin, or to a Tendon, or Ligament.

As the power of repairing injuries depends on the vigour of the circulation that parts possess, that power is in a greater or less degree, in proportion as they are more or less distantly situated from the source of circulation; and hence Ulcers on the superior part of the body heal more readily than those on the lower extremities (from their being near the source of circulation). Blood then is that fluid by which the injuries of the Machine are repaired. Some have said that the Blood is merely mechanical in the system, and circulation performed on Hydraulic principles, and that any fluid circulating will preserve life as well as blood, but from experiment I found this not to be the case and that any fluid circulating will not answer as a substitute for blood. I opened the Carotid artery of a Dog, and after he had lost a quantity of blood, some beer was injected, and I thought the Dog lived longer than he would have done if nothing had been substituted for Blood; yet I am inclined to believe that this was mere fancy, for I made the experiment and kept the Artery distended by injecting warm water to supply the loss of blood, & could not

observe that the dog lived longer than might have been expected, if nothing had been injected. But though no other fluid will answer as a substitute for blood, yet blood taken from one animal and conveyed into another will support life.

LOWE, first introduced this practice into this country about 130 years since, and which is called transfusion.

An animal has been bled almost to death, & yet by receiving blood from another has been restored.

This has been repeatedly done - I carried these experiments to a great extent and found them true, and found also that blood from different animals answered as well as that from the same species. In one experiment I exhausted the animal so completely of its blood, that no pulsation could be felt, and it was apparently dead, but supplying it with blood it recovered contrary to the opinion of Mr. Ashley Cooper who was present. But how far may this be made subservient to useful purposes? The experiment has been made in France and failed, this was probably owing to too great a quantity of blood being introduced which caused a Plethora; the abuse of a thing does not destroy the usefulness of the practice. - It might perhaps be advantageously employed to recover still born Potuses if had recourse to in ten or fifteen minutes after birth, or might be transfused into subjects who have

died from a sudden loss of blood, as in case of *Felo de se Menorrhagia* &c. — This appears very probable and ingenious, but prejudice makes against it. — — — — —

LECTURE 15th

On the Structure and Economy, of the Heart.

We have already considered the Nature, Properties and importance of the Blood, but that the purposes of the Machine may be answered, it is necessary the blood should be kept in constant motion, as well to supply the growth of the solids and their exhaustions, as the waste occasioned by the secretions. Hence we are led to consider the circulation of the blood. No one doubts of the motion of the blood and if we open vessels near the Heart and others at various distances from it, we shall find that the velocity is greater the nearer it is to the heart, and diminishes in proportion to the distance from it. From this it appears that the heart is the principle organ concerned in the circulation. We shall therefore premise something with respect to the Structure of this organ, before we shall speak of the circulation of the blood. Let us first consider the heart in its simplest sense. — We may define

it to be a muscular cavity, communicating with vessels to propel and return blood. The heart of some Animals has four cavities, others only three, some as Fish have only two, Oysters have only one, and the Leech and many Insects have no heart. In these last there is a cavity for receiving their food, and two vessels, by one of which it is taken in, and by another carried out. The fluids in these Insects are carried, and deposited, from a kind of Absorbent Vessel in the Stomach, and as we do not know how they are returned, we cannot speak of their circulation. The Heart is situated in the cavity of the Thorax, and is contained in the Pericardium. It is chiefly retained in its situation by those reflections of Pleura which form the Mediastinum and is fixed also at its base by the Vessels going from it.

The Apex of the Heart is not bound down like the basis and has therefore most motion. It is placed somewhat obliquely across the Chest, the basis being the superior part, and lying towards the right side; and the Apex to the most inferior part lying towards the left side. The pulsatory motion is felt during the Systole or contraction of the Heart, between the fifth and six ribs, for the Auricles being situated at the basis when they are distended it forcibly pushes the Apex forward. The Pericardium which forms a loose bag for the Heart by being reflected also gives it

a more immediate covering. Besides serving to keep it in its situation, it secretes likewise an interstitial fluid to lubricate and facilitate its motion. The figure of the human heart is different from that of other Animals; though the structure and economy are the same. In Man it is nearly of a conical form, but flat on one side, and in brutes it is still more conical. This difference is owing to the peculiar form of the Chest. In the human a line drawn from the Spine to the Sternum is shorter, than one drawn from side to side, and this structure confines the heart and requires a flatness on one of its sides.

In Brutes the reverse obtains, which gives room to the Heart, and admits its being more conical.

As the Heart is the principal organ of circulation it must therefore have Vessels communicating with it, some to bring blood to it, and others to carry it away; all these communicate with the Heart and its base.

The Heart of itself is composed of four cavities, two of which are called Auricles, and the other two Ventricles.

It is common to speak of the right and left Auricle and Ventricle; but from their situation it would be better to call them Anterior and Posterior. Some call the Auricle Sinus, (meaning one Sinus) of the Vena Cava, and the other of Vena Pulmonates, considering

them no more than appendages. The vessels communicating with the Auricles are veins, and those with the Ventricles are Arteries. The Veins entering the Auricles are six in number, the two Cava entering the right, and the four Pulmonary the left Auricle. The Arteries only communicate with the Ventricles, the Pulmonary with the right and the Aorta with the left. The Veins bring blood to the Auricles and the Arteries carry it from the Ventricles. If we consider the structure of the Heart, we shall see that this must be the case.

It is an organ muscular and irritable in every part, but not equally so, there is also some difference in the cavity of the two sides of the Heart, and of course there must be a difference in size of the vessels going from each.

The Auricles are much thinner and less Muscular than the Ventricles, and the right is less so than the left.

It may be asked why there is this difference? It seems a law of the Animal Economy, that no part shall be furnished with more of any thing than is necessary for the discharge of its functions. The Auricles when distended with blood by their contractions force their blood into the Ventricles, and as these lie so very near each other, little force is required for that purpose. Again the right Ventricle being distended with blood, has to send it to the Lungs, the distance in this case is much greater than in the former, and therefore more force is required,

and hence we find that the right Ventricle is much more muscular than the Auricle, but the left Ventricle has to send its blood to every part except the Lungs. And here therefore a greater force is required, and accordingly the left Ventricle is found to be much more muscular than the right.

The Heart when cut open shews a particular Mechanism, which determines the course of the blood to be such as we have described. Indeed it is rather singular that the circulation was not sooner discovered on this account, considering it has been in contemplation near two thousand Years. The Valves are the part which determines the course of the blood. Where the Auricles and Ventricles are communicating there is fixed a Membrane which projects into the cavity of the Ventricle, and is so contrived as to let the blood readily pass from the Auricle into the Ventricle, but should it offer to return, the Membrane would be raised up and obstruct its passage. These Valves have different names from some particularity in their structure, nevertheless they perform exactly the same office. On the right side the Valve is composed of three portions of Membrane, and hence called Valvula Tricuspides; that on the left side only two portions which project in such a way as to resemble a Mite and hence they are called Valvula Mitrales.

The outside of the Heart is smooth, but the inside fascicular.

and is composed of a number of fleshy columns which are called *Carno Columnae*. What advantage arises from this kind of structure? It must be remembered that the contractions and dilations are not gradual like those of the Stomach and Bladder, but sudden and frequent.

It seems then the disposition of the fibres makes the heart more capable of performing these sudden contractions.

From the *Carno Columnae* pass a number of tendinous fibres, called *Cordo Tendinosae* to be inserted into the Valves.

These strengthen the Valves and should the blood regurgitate and prevent them from being forced farther than the Axis of the orifice between the Atricle and Ventricle. Besides these Valves there are others at the beginning of the large Arteries the Pulmonary and Aorta. In each of these there are three they are of a Semilunar form, and therefore called *Valvulae Semilunares*, they appear to be doublings of the internal coat of the Arteries; when the blood is forced from the Ventricles into the Arteries, the Valves lie close to the sides of the Vessels, but should the action of the Vessels drive the blood back, they would meet in the centre, and by closing up the passages prevent its return. There are many means by which it can be proved that the Valves perform this office, but by none better than by injecting the Arteries contrary to their course.

Having premised these general observations with respect

to the Structure of the Heart, we are better prepared to speak of its Economy. The circulation of the blood which has already in some degree been anticipated; There is some part at which we must begin, it is quite indifferent where, as it is like describing a circle. We will say however that all the blood is sent from the heart to the different parts of the body except the Lungs, by the Aorta and its numerous divisions and subdivisions. The ramifications are at last so minute that they are called Capillaries.

These terminate in Veins by continuation of canal, so that we cannot say where the Arteries end, and the Veins begin. They may be called Veins as soon as the blood begins to return. The Veins unite to form larger branches, and at last form two very large ones, the Superior and inferior Cava, by which Vessels all the blood which is distributed by the Aorta is returned into the right Auricle of the Heart. The superior Cava returns the blood from the head and Trunk, and the inferior from the other parts of the body. These Vessels enter the Heart obliquely at an acute angle with respect to each other, which is favourable to the entrance of the blood by preventing an opposition of streams. When the Auricle contracts what prevents the blood from regurgitating into the Veins? It does regurgitate in some degree and this is the cause

of that pulsatory motion in the Jugular & other large Veins near the heart, but the *Vis a tergo* prevents it from taking place in any considerable degree. Besides in the inferior Cava there is something like a Valve in a crescent shape, but from its size it cannot prevent the regurgitation of the blood.

It is called *Valvula Eustachii vel-nobilis* and seems principally concerned in the fetal circulation, as it is often wanting in Adults. The right Ventricle being filled contracts and drives the blood into the Pulmonary Artery and it is prevented from returning either into the Auricle or Ventricle by the Valves already mentioned.

The Pulmonary Artery divides into two branches one going into each Lung, and there by a ramification carry the blood through the Lungs. It is then returned by Veins which terminate in four large trunks called the Pulmonary Veins, in the left Auricle forming nearly a square. But here regurgitation in part takes place as in the Vena Cava, from the want of valves, but by the *Vis a tergo* it seems to answer the final purpose.

The left Auricle being distended contracts and forces its contents into the left Ventricle and is then propelled into the Aorta, and is here prevented from returning by Valves similar to those of the Pulmonary Artery. By the Aorta as was before said the Blood is distributed through the body.

(Thus we have traced the blood through its double circulation, but it may be well again briefly to relate its course.)

The blood then is returned from the different parts of the body, by the two Vena cava into the right Auricle, this by its contraction sends it into the right Ventricle, from whence it goes by the Pulmonary Artery through the Lungs; it is returned from the Lungs by the four Pulmonary Veins into the left Auricle, from which it passes into the left Ventricle; by this Ventricle it is drawn into the Aorta which distributes it through the body. There are four cavities in the Heart all of which contract; but are there four successive contractions? No, there being two distinct circulations going on at the same time; the two Auricles are filled at the same instant, they contract and fill the Ventricles, which are then stimulated to contract, so that the Auricles and Ventricles contract together alternately, (but though the actions are thus alternately with each other) this is observed to be the case on opening a living Animal. Upon each of the Valves is a small dot, called Corpus Testiculoides. The use of these is most probably that of completely filling up the space between the Valves, for when the circular edges of the Valves are placed together, there will be a small space left. These bodies do not however seem of much importance as they are often hardly

discernable. The Blood we have been tracing through the Heart does not at all contribute to its nourishment. The Heart is nourished by two arteries which from their manner of distribution are called Coronary Arteries. They arise from the Aorta as soon as it has quitted the left Ventricle. They ramify through the Heart, and their blood is returned by the Coronary Veins, which terminate in the right Auricle by open Orifices. The Coronary Veins have Valves to prevent the regurgitation of the blood from the Auricle.

(So far have we considered the Heart mechanically, as to its action.) But where is the origin of this action, or in what does it consist? Most Machines act from a power exterior to themselves, but as it respects the Heart, the very fluid it is intended to move is that which first excites the motion. If we inspect the Heart of living Animals, we see a regular alternation of action, but as soon as the Lungs collapse the action of the Heart begins to cease. First the left Ventricle fails, and then the Auricle which continues its action for some time after the Ventricle. Why does this take place? Is it the *Ultimum Moriens*, the last dying speech & confession of the Heart? No, it may be better explained. The left Ventricle is the most muscular, & consequently

empties itself more forcibly of its blood, and the left Auricle being weakened from the collapse of the Lungs, and not receiving its supply of blood through it to the Ventricle. In consequence the Ventricle first fails and then the Auricle. The cessation of action on the right side of the Heart takes also place first in the Ventricle, and then in its correspondent Auricle.

It is here also the greater muscular force of the Ventricle emptying itself sooner than it can be supplied with blood by the Auricle. And the Auricle receiving blood longest it continues its action longest. But if a Ligature was made to stop the blood from flowing into the right Auricle it would cease to act quite as soon as the left did in the former instance.

Hence it is not from any particular vitality that one part of the Heart ceases to act before another, but from its not receiving blood so long which seems to be the proper stimulus to action. The Heart is muscular and nervous, and its action is involuntary, yet though the Will has no power over the Heart, the passions have. If in the Voluntary muscles the nervous communication be interrupted, all volition & sensation is lost, but the part may still possess irritability, and this the Heart has in a great degree. Hence has arisen a question, whether nervous energy was necessary to the action of the Heart.

I think there can be no doubt of this notwithstanding it has more irritability than other parts. We spoke of the

Stimulus of the blood exciting the Heart to action, and of a deficiency of this to produce a collapse, and of the Lungs causing a cessation of action, so the redundancy of it will have the same effect. The Heart may be filled and distended with Venous blood as to have its natural action overpowered and a removal in part of this blood would allow the Auricle to contract and act as before. Syncope may arise from this cause, as well as from defect of blood in the Auricle, as often happens in blood letting, but this is obviated by laying the body in a supine position, as that favours a return of blood from the lower extremities and of course supplies the deficiency. It sometimes happens in a rupture, or wound in a large Vein, that the blood is suddenly discharged and if lost in this sudden way will presently cause death: (one pound of blood lost in this way would produce death.) Whereas a much greater quantity may be lost without injury by taking it away in a more gradual manner. It is on this principle that bleeding people from a large or small orifice disposes more or less to Syncope, but the operation of fear also is sometimes very great. - - - - -

LECTURE 16th

Action of the Heart considered.

We have hitherto considered the heart as inanimate, and viewed the passage of the blood through it as depending on its Mechanical structure, such as would take place in the passage of a fluid through an Hydraulic Machine of a similar construction. But the Heart as a peculiar action inherent in itself depending upon a peculiar stimulus, to consider which will be our present business.

Before we proceed it will be necessary to establish some facts relative to the action of the heart. If we open the Chest of a living Animal the Lungs immediately collapse owing to the pressure of the external air. At first we see the actions of the Heart very evident, and that the actions of the Auricles and Ventricles are alternate.

In a very short time we see the contraction of the left Ventricle to intermit, and perhaps it contracts once to three times of the Auricle. The length of the intermissions increase and presently the action of the Ventricle entirely ceases.

Soon after this the action of the corresponding Auricle seems disturbed, and it first intermits and then ceases in a

similar manner with the Ventricle. Now the right side of the Heart is only in motion and in a few seconds the same begins to take place in it as has done in the left, the right Ventricle first intermitting and then its action ceasing, and lastly, the right Auricle ceases also. From this it appears that the action of the Heart does not cease in every part at the same time, but in the order that we have mentioned.

On this account many have supposed the right Auricle was most tenacious of life, and have endeavoured to support the Idea that the right side of the Heart possessed more irritability than the left. While the Lungs are in action, the blood has very easy transmission through them, but it was observed that in opening the Chest external Air rushed into the cavity and caused them to collapse. When this has taken place the blood is prevented from passing through them with that freedom it did before, and consequently a less quantity of fluid is sent to the left side of the heart which nature intended as its proper stimulus. - - - -

The Auricle being much less than the Ventricle, requires a smaller quantity of blood to make it contract, and therefore the Ventricle ceases first. The blood coming to the right side of the Heart not passing through the Lungs has not of course its passage impeded, and in consequence the action of that side is longest. This appears to be the reason, but

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we should offer some proof. If we could so order that the left side of the heart should be the longest supplied with blood, and then find the reverse of what has been stated to take place, it would be proving as much as an experiment can prove. I opened the Chest of a Dog having previously prepared ligatures to tie his Aorta. The only dissection necessary was to divide the Pericardium where it covers the Aorta. This being done the Vessels of the right Auricle were tied without farther delay and pressure was made on the superior and inferior Cava to prevent the blood from passing into the right Auricle, and a small opening was made into the Vena Cava inferior. . . .

Thus the left Auricle and Ventricle were prevented from being emptied by the ligature on the Aorta, and the right Auricle and Ventricle from being filled by the pressure of the two Vena Cava. The opening in the Cava inferior permitted the right Auricle and Ventricle to be emptied of their blood and the natural order of the circulation was in this way reversed. In this case the right Ventricle ceased first to act, after it the Auricle of the same side, then the left Ventricle, and lastly, the left Auricle. The Auricle will sometimes contract two or three times, while the Ventricle contracts once, but this only when the powers of life are diminishing. It may be accounted for in this way.

The Atricle being weak cannot empty itself by its contractions and therefore repeatedly contracts, but the Ventricle being more muscular and irritable has power enough to empty itself by one contraction. From what has been said it appears, that nature has given the Heart great muscularity, and that by the addition of life it is rendered very irritable. It appears also that the blood is the proper stimulus of the Heart. The action of the Heart is diminished by a sudden diminution of blood, as well as by a sudden influx over distending it: hence some people in using violent exercise, by the muscles pressing on the Veins and causing them to return their blood in greater quantity by the Cava into the right Atricle, may so fill it, that its action cannot go on. The Mind acts in the same way, determining blood to the Heart in too large a quantity. Mr. Hunter in part died from this cause, for being by some difference with the other Surgeons thrown into a violent passion, more blood was sent to his Heart in consequence, and this to when his Heart was previously diseased. That this effect is produced has been proved by experiment. A large quantity of blood was thrown into the Heart of a Dog and its action ceased, but on making a puncture on the inferior Cava, so as to allow some of the blood to escape, the action was immediately restored, and on this principle Syncope was

explained. We also know however that a person is much more liable to faint in an upright, than in an horizontal posture, for in an upright posture an equal quantity is not sent by the inferior Cava to the Heart owing to the resistance given to its passage, by having to mount contrary to its gravity, but an horizontal position taking off that resistance favours the passage of the blood. Besides the obstruction to the blood in an upright position it may be added that the blood drawn from the Arm necessarily prevents so much blood, passing by the axillary Vein, and the Cava superior, hence the Heart is deprived of blood from each Cava, so then in this case Syncope arises from deficiency, while in the former it did by too great a quantity of blood. The heart is not uniformly as was observed in a state of action, but there is a momentary cessation between each contraction. There are some opinions relative to the cause of this that deserve notice.

Galen thought the Heart acted from habit. Some have thought it was a Paralytic affection; Boerhaave was of this opinion and he endeavoured to account for it from the pressure of the Heart on the Plexus of Nerves situated between its base and the Spine when in a distended state, which he supposed produced a momentary Paralysis. Such an opinion however is to be regarded

only as an ingenious Hypothesis. It cannot be proved nor decidedly disproved by experiment but what we know militates against it. Voluntary muscles may be rendered Paralytic by pressure, but involuntary ones of which is the heart will act for some time after the communication with nerves is cut off. The Heart will act indeed a short time after it is taken out of the body. Besides when a part is rendered Paralytic by pressure, its power of action is not entirely restored upon the removal of it. In addition to these objections the softness of the parts concerned would not affect this pressure, and if they did the irritability of the Heart would cease it to go on notwithstanding. The action of the heart does not appear to be so intimately connected with the nervous influence as most other Muscles. If we stimulate the nerves going to the Heart its action is not increased, but this is not the case if you stimulate the nerves going to the extremities.

The Cardiac Plexus of nerves which supplies the Heart is formed by the Par Vagus. and Sympathetic Nerve.

We have very easy access to the former and if we stimulate it no difference is perceptible in the Heart. Some have thought the Heart would act as well without as with Nerves, but this does not appear consistent if we reason from the Analogy of the parts. It is true the greater irritability of the Heart will cause it to act longer without the nervous influence

than any other part; but nevertheless it cannot be continued for any length of time. Experiments have been made to determine with what force the Heart acts by placing weights upon it, and the utmost weight it could move was supposed to be an estimate of the force of its action. These experiments are rather whimsical and cannot with any certainty ascertain what was wished. That the force of the Heart's action is very great may be proved by experiments. I compressed it between my hands when no force that I could use would stop the action immediately. This force will vary in different animals, and in the same animal at different times. The propulsion of the blood does not belong to the Heart alone, the Arteries assist in this office.

We know that the motion of the blood may partially accelerate and this cannot belong nor depend on the action of the Heart. That effusion of the face which we call blushing does not depend on the action of the Heart, but in a peculiarity of action in the Vessels of that part. Inflammation we also believe to be the increased action of the Vessels of a part. There have been instances where the Heart has been wanting in the Fetus, and yet the parts that were present have been nourished quite as well as those with perfect Hearts. I have dissected two

Monsters, where the Heart, Lungs, and indeed the whole
 upper part of the body were wanting, and yet the other
 part of the body were as large as other Children at
 birth. This proves that the Heart is not necessary for
 fetal circulation and existence, but such monstrous
 productions die as soon as they are born, for want of
 Lungs. The structure of the Arteries confirms the
 Idea of their assisting in the circulation, and this more
 or less in proportion to the distance the Artery is from
 the Heart. This structure of the Arteries is of great im-
 portance to the circulation for there is a distance from the
 Heart at which the blood is very little affected by its
 action. By giving Muscularity to the Arteries in proportion
 to their distance from the Heart, it seems as if nature
 in some measure to equalize the circulation had
 previously intended that which would otherwise
 have been very irregular. Experiment proves that
 Arteries have action. We cannot make an injec-
 tion which is finer than the blood return in any
 considerable degree by the Veins, notwithstanding the
 force used by a Syringe is greater than that of
 the Heart. By injecting Animals alive the small
 force of a Syringe would not only inject the Arteries
 but even the Veins. This strikingly proves the action

of the Arteries, and though that action is not in any part great, yet from the number and minuteness of the Vessels an extensive surface is exposed. In very large Animals the Muscularity of the smaller Arteries is very great. If you take a piece of Artery from the leg of a Horse it appears a strong nearly impervious cord, having a very small orifice in its centre. If any substance is introduced into it to enlarge the opening, it does not become so close as before, which proves that the contraction did not depend on the Elasticity of the Artery alone, but partly on its Muscularity, for Muscular fibres we know though not elastic, are still ductile.

Of the greater Circulation.

When we spoke first of Circulation we observed that it was double, there being a smaller one through the Lungs, and a larger one through the rest of the body; having finished respectively the action of the Heart, we think the greater circulation is a subject which will with greater propriety follow the History of the fetal Circulation.

Lecture 17th

The Fetal Circulation.

We now come to speak of the peculiarities of the Fetal Circulation. The Fetus has not only a circulation in common with the Adult, but also one peculiar to itself. The peculiarity depends on certain apertures and canals which do not exist in the Adult.

Before we speak of these it will be necessary to make a few observations relative to the connection between the Mother and the Fetus. The Uterus is well supplied with blood from the Internal Iliacs. The Vessels of this organ after ramifying through it, deposit their blood in the Cells of the Placenta or Maternal part; for the Placenta is composed of two parts, the Maternal & Fetal - - -

From these Cells the blood is taken up by the Veins, and returned to the Mother, having no communication with the Fetus, the Umbilical Arteries is in the internal Iliacs, pass through the Umbilicus, and distribute their blood to the Fetal part of the Placenta. The blood is returned to the Fetus by the Umbilical vein. It appears then that the Vessels of the Uterus have no communication

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with those of the Fetus. This is further proved by throwing in a minute injection, but this subject will be further spoken of at another time. The Umbilical Vein having passed the Umbilicus goes in to the Liver where it divides into two branches, one called ductus Venosus passing to the inferior Cava, and the other into the Vena Portarum which is going into the Liver and carrying blood for the Secretion of Bile.

When the blood has passed through the Liver it is conveyed by the Hepatic Veins into the inferior Cava, just before it enters the right Auricle. The blood of the Umbilical Vein therefore gets into the right Auricle, either directly by the ductus Venosus, or indirectly by the Hepatic Veins after having passed through the Liver. In the right Auricle it mixes with the blood of the superior Cava. In the Adult this blood is sent into the right Ventricle, but in the Fetus one third passes into the left Auricle, by an opening called the Foramen Ovale, situated in the Septum dividing the left Auricle from the right.

The Foramen Ovale is situated obliquely in the Septum as to answer the purpose of a Valve, and thus prevent the return of the blood into the right Auricle. The rest of the blood being about two thirds of the whole, goes into the right Ventricle and from thence it is sent into the Pulmonary Artery. In the Adult all the blood that enters

into the Pulmonary Artery circulates through the Lungs, but in the Fetus it is not so, for the Lungs not having performed the functions of Respiration are in a collapsed state, and require but little nourishment. — — —

By far the largest quantity of Blood passes in consequence through a large Vessel called Canalis Arteriosus which goes from the Pulmonary Artery directly into the Aorta. The small quantity that circulates through the Lungs, is returned by the Pulmonary Veins to the left Auricle. It does not in its passage through the Lungs undergo any change as in the Adult, but seems rather designed for the purpose of nourishment, or for keeping the Vessels pervious for future circulation. About one part in three passes through in this course, and the other parts go through the Canalis Arteriosus. The blood in the left Auricle is sent into the left Ventricle and from thence passes down the Aorta by the side of the Spine, till it gives off the Umbilical Arteries by which the blood is carried into the Placenta, so that the blood is brought to the Fetus by the Vein, and returned from it by the Artery. The purposes answered by these peculiarities in the Fetal circulation cannot at present be entered into at large from their depending on some circumstances relative to respiration. It seems however that since the Lungs cannot

breath, the Placenta performs that change in the blood that the Lungs do afterwards, for if the Umbilical cord be compressed so as to prevent the flow of blood through it, the Child will die in ten or fifteen minutes. After birth several important changes take place. First the Child has a struggle for breathing, afterwards and in consequence of Respiration being established and carried on, the Vessels and apertures peculiar to the Fetus close up, but these are gradual changes. — — —

When air is taken into the Lungs they must be very much increased in size, and their vessels which before coiled up must become larger and more pervious. The blood now passing much more freely through the Lungs than the Canalis Arteriosus, the quantity passing through that canal will gradually diminish, and this like all other Arteries having the power of adapting itself, to the quantity of blood passing through it becomes by degrees obliterated. The Foramen Ovale disappears about the same time & from the same cause, though sometimes this aperture does not completely close, more blood being brought by the Pulmonary veins into the left Auricle than before Respiration took place, it becomes of course more filled and gives resistance to the passage of the blood from the right Auricle through the foramen Ovale, & as the resistance increases, the Foramen Ovale becomes closed. The Umbilical Arteries being tied at Birth the blood that passes through them

must find some other course which it does by the external Iliacs. This accounts for the growth of the lower extremities after birth being greater and nearer in proportion to the rest of the body, for it is evident that the lower extremities of Adults are larger in proportion to the rest of the body than those of new born Children. The Umbilical Arteries then having got rid of their blood, by their contractile power soon become closed. ~~but much more closed~~ The Vein also being in some degree muscular becomes closed but much more gradually. I have known it pervious in a ~~person~~ ~~person~~ person sixty years old, it is this vessel in the Adult which is called Ligamentum rotundum of the Liver.

The Canalis venosus closes likewise in consequence of these other changes. The Heart is not necessary in the Fetal circulation, and it indeed never is where the Lungs are not in action, and where the Lungs are wanting, the Heart also is wanting. Several monstrous productions have been known without either Heart or Lungs. - - - - -

Circulation in Amphibious Animals.

The word Amphibious is used in a very vague and indefinite sense. It is therefore necessary to explain what is understood by it. Those Animals which live near lakes and often swim in them as Otters &c, have been called Amphibious, but these have only Lungs & Hearts like other

Animals; Turtles, Frogs, Toads and Lizards have been more properly termed such, but even these strictly speaking cannot be called Amphibious, for they may be easily drowned by being kept under water for a certain length of time. By Amphibious Animals according to the true sense of the word are meant, such as can live either in Air or Water for any length of time.

We know but of one Animal of this kind, the Tunny.

This is said to have a Heart and Lungs like other Brutes & also Gills like a fish. It could not live otherwise any more out of Water than land Animals can live in it. The Gills of Aquatic Animals have a power of imbibing a property from Water which will produce the same change on their blood, as the Air does in Land Animals. What we are at present to speak of is the circulation of those Animals which can live a long time under water, as Turtles, Lizards &c, they have very large Air Balls which enable them to live under water a very long time, but we shall speak of this hereafter. In these Animals a part only of the blood passes through the Lungs at each circulation. Some therefore have thought their circulation to be like that of the Fetus, but it is not so. They have properly speaking but three cavities in their heart, for between the Ventricles is a large aperture of communication, so that the Pulmonary Artery and Aorta go off from the same cavity. The blood is returned from the body into the right Auricle by one Cava vein, and from the Lungs by the Pulmonary

veins into the left Auricle. The Aorta is a great deal larger than the Pulmonary Artery, so that part of the blood that passed through it in the former circulation must again pass through it, hence but a part of the blood circulates through the Lungs at each circulation to receive its change there. In the opening between the Ventricles is a Valve so placed as to direct nearly all the blood that had circulated through the Lungs into the Aorta, so that though a small quantity that had circulated through the Lungs may be sent there again without having gone through the body yet it is very little. Fish have but a single Heart, viz, one Auricle and one Ventricle. The blood is brought into the Auricle by a Vein, from whence it is poured into the Ventricle. From the Ventricle it passes by the bronchial artery (which answers to the Pulmonary Artery) to the Gills. From the Gills after circulating through them, it is returned by veins which join to form an Artery, answering to our Aorta, by which the rest of the body is supplied. In many Fish as the Cod, the branchial veins are distributed over the body without being previously united into one large trunk. The Lobster, Oyster, Inail &c have but one cavity in their Heart which has two vessels communicating with it, one by which the blood is returned from the body, and the other by which it is distributed to the Body.

Lecture 18th

Of the Greater Circulation.

When we first spoke of the Circulation we observed that it was double, there being a smaller one through the Lungs, and a larger one through the rest of the body.

We have finished what was to be said of the smaller, both in the Adult and in the Fetus, as well as in many Animals, those that are called Amphibious and Fishes.

We have also considered the Heart as an organ of Motion, and it now remains for us to take a more particular view of the Greater Circulation. This includes the passage of the blood from the left side of the Heart, and after its pervading the System, its return to the right side of the Heart.

The first vessel considered in the greater circulation is the Aorta, which goes off from the left Ventricle, and passes through the trunk in such a manner most convenient for giving off branches to supply the different parts of the body. The Ancients thought the Arteries were intended to carry air. They had an Idea that they had communication with the Air by means of the Lungs. The circumstance that gave rise to this opinion was, that these vessels are always

found to contain Air after death; hence they derived their name, the word Artery signifying Air tube.

Galen first discovered that Arteries contained blood by opening living Animals. They accounted for the blood getting from the right side of the Heart to the left by the foramen ovale. This Idea they probably took from examining the Fetus. It is now well known that the Arteries carry blood; But why are they empty after death? There is always some blood found in them and the quantity depends on the action of the Lungs. The last action after life is expiration, hence to die and expire are Synonymous terms, so that after death the Lungs are in a collapsed state in which the passage of the blood through them is interrupted. Thus the blood is accumulated in the Vena Cava, and prevented from getting into the Aorta through the Lungs, which assisted by the contractile power of the Arteries themselves causes them to be empty after death.

This reasoning is confirmed by facts. A case is related of a person who was suffocated after a full inspiration, & in whom upon dissection the blood was found in the Aorta.

The same took place in some experiment made by Mr. Coleman. The Aorta divides into two branches, which subdivide into others, and these again into smaller & smaller till they end in Capillaries which are the smallest vessels that carry red blood. In this manner the blood is carried to

the remotest parts of the body. In the Capillaries the blood takes a retrograde course towards the Heart by Veins which are a continuation of Canal from the Capillaries. That this is the course of the blood is very easily proved by experiment. One made by Harvey was tying a ligature on an Artery & Vein.

This is the celebrated experiment that led Harvey to the discovery of the circulation of the blood. It was first made by Vesalius though Harvey had the merit of drawing the conclusion from it. The Artery was observed to swell on that side the Ligature nearest the Heart, and the Vein to collapse, and Vice Versa. Some have made an objection to this experiment by saying that this Phenomenon does not always take place. It is true that on many parts if a Ligature be made on a Vessel, no accumulation will take place, but it must be in those parts where the vessels must have a number of Anastomosing branches, as in the Mesentery.

For the same reason there will be no collapse on the other side of the Ligature for the blood will take a retrograde course as far as the Ligature. A knowledge of the parts in which this will take place seems a matter of curiosity; but it is of real importance to every practical Surgeon.

For instance if a Ligature be made on the radical Artery, there will be no collapse between it and the hand owing to the free communication between that Artery and the

Ulnar by means of the Arch in the palm of the hand.

This suggests to us the Idea, that if the Radial Artery is at any time divided, an accident which sometimes happens, a Ligature on the upper orifice of the Vessel would not stop the Hemorrhage and therefore either a Ligature or pressure on the lower orifice would be necessary. I once saw a case where the posterior Tibial Artery was divided by a Knife plunged in through the Gastrocnemii Muscles. The Surgeon applied a Ligature on the upper orifice of the Vessel, but the Hemorrhage continuing nearly as violent as before, he thought nothing could be done to save the Patients life but Amputating the limb; on dissecting the limb after Amputation no other cause for the continuance of the Hemorrhage appeared than the lower orifice of the Artery being open, which has a free communication with the planter Arch or Anastomosing branches with the Tibial; had this been taken up the Limb might have been saved. Perhaps there is no proof of this circulation more striking than seeing it in transparent parts, as the web of a Frog, the tail of a Fish, Lizard &c. These may be so placed under a microscope that the blood may be seen going by the Arteries and returning by the Veins. The flow of the blood through the Arteries is not in an Uniform manner but by Saltations which however are much more apparent in some Arteries than in others. In the large ones they are very evident, in the small ones less

so, and in the Capillaries not at all. This is easily accounted for.

The Ventricle contracting sends a column of blood into the large Arteries which contracting send it forwards; Another column is sent to them and forwarded in the same manner.

The Arteries cannot empty themselves entirely by their own action, so that if an Artery be divided at some distance from the Heart, the stream will not be entirely interrupted by the action of the vessel, but will at the same time of the contraction of the Heart be projected further. In the Toes very little difference is observable in the distance to which the blood flows when an Artery is divided. Harvey thought there was a spongy substance called Parenchyma between the termination of Arteries and the beginning of Veins. —

No such substance however can be found in the general termination of Arteries, but in some particular parts we find such. That no Parenchyma exists is proved by injecting an Artery in a transparent part as the Intestines, or web of a Frogs foot, when it will be seen that the injection passes directly into the Veins. Instances of Parenchymatous structure are the Corpora Caverosa Penis, the Clitoris, Spleen, Placenta &c in which the Arteries terminate in cells, from which the Veins takes their origin.

There are some Animals which have the power of increasing particular parts at pleasure, such as Cocks,

Turkeys, &c, and in these also the Arteries terminate in Cells.

In general we observe this termination in parts, where a slow circulation is required. It was formerly observed that blood was composed of different parts, *Viz.* Serum, Coagulable Lymph and red particles. Some Vessels are so small, as to admit only the two former and exclude the red particles, which has given rise to a division of Vessels into Languiforous and Seriforous. A second termination therefore of Arteries may be said to be in Seriforous Vessels. This is a useful contrivance for supplying with Nourishment those parts whose functions would be interrupted by red blood. As for instance, the transparent Cornea. Though the Cornea cannot be proved to be organized by injection, yet it appears so from the power of healing after wounds have been inflicted in it, as in extracting the Cataract. The Tunica conjunctiva, exhibits a Specimen of both kinds of Vessels, in the natural state it is transparent being supplied with Seriforous Vessels, but from inflammation the Vessels become turgid and admit red blood so as to become uniformly red. This redness is not produced from Extravasation, nor the formation of new parts, but as was said by red blood being poured into the Seriforous Vessels, and this may properly enough be called an Error

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loci. — Arteries also terminate by open Mouths and are then called exhalents. These are to be found in almost every part of the body, both on its surface and internal parts. The fluids pass off by them so slowly that it is not evident at the time, but their office is proved by its often being accumulated in cavities, as the Ventricles of the Brain, Thorax, Abdomen &c. In these a fluid is exhaled to lubricate them continually and thus obviate the effects of friction by motion. The Cellular Membrane is plentifully supplied by exhalents as are all other parts where there are motions. — — — — —

In the Cellular Membrane it is necessary in order to lubricate the parts for the easier action of the Muscles, and that it exists here is often proved by its too great accumulation which constitutes an Anasarca.

To take up the surplus of fluid poured out by the exhalents, we have another set of Vessels the Absorbents. When from any cause the action of the exhalents is increased, or that of the Absorbents diminished, an accumulation of fluid takes place constituting Dropsy, which has different names according to its situation. In some parts of the body the fluid is not intended to be taken up, as in Perspiration. The fluid carried off by exhalation from

The Skin is according to the experiments of Sanctorius very great; and so it is likewise from the Lungs.

The Air thrown out by the Lungs always contains a quantity of Moisture which in general is imperceptible, but when the surrounding Atmosphere is so cold as to condense the Moisture, it is easily seen. - - -

When an Animal is hot and perspiring freely, it appears enveloped in a Cloud; which is owing to the condensation of the fluid, the Atmosphere being at this time much colder than the Animals body.

Every Animal is not subject to this Emissary by the Skin, in Dogs, in whom it seems confined to the Tongue. A fourth termination of Arteries is in secreting organs. Many surfaces exhale fluids whose properties are quite different from the blood, but which are secreted from the blood, such are the Mucous Membrane of the Nose, the Urethra &c. They not only secrete the fluid but afterwards throw it out; and hence may be called not only secreting, but excreting organs.

But secreting organs more accurately speaking are Glands, as the Testes, Salivary Glands, Female Breasts, &c. Another and fifth termination of Arteries which should not be overlooked as in Nutrient Vessels. - - -

There is a constant waste of Solids which is to be

supplied by blood. When any wound is made, the deficiency must be made up by the blood. For this purpose Vessels terminate in parts which require such supply. Likewise Arteries terminate in open mouths which are not exhalants. This is the case in the Uterus the Arteries of which give the Menstrual secretion.

This secretion although red has not all the properties of blood, never coagulating, from not possessing coagulable Lymph. — — — — —

Lecture 19th

Circumstances affecting the Velocity of the Blood.

The motion of the Blood is more rapid in the large Arteries than in small ones, which is owing to the Aggregate area of the latter being greater than that of the former.

For instance, if we take an accurate measurement of the Aorta just before it divides, and of the two Iliacs afterwards, we shall find that the aggregate area of the Iliacs is greater than that of the Aorta. The capacity of the canal being increased, the Velocity of the fluid must consequently diminish. In the further division of the

Iliacs the same takes place, and therefore the Velocity of the blood in the Aorta must be much greater than it is in the Capillaries. Again the Angles at which the Vessels arise affect materially the velocity of the Blood. ---

The Carotids go off rather at obtuse angles, the Intercostal nearly at right angles. The Iliacs rather form an acute angle, and the Vessels of the extreme parts form angles still more acute. This construction appears in some degree intended to equalize the circulation, for resistance given to the force of the blood is in proportion to the obtuseness of these angles, and we find therefore as the moving powers are least in small Vessels, the resistance is least also. If a ball be projected in a right line its velocity will be greater during its course, than if it was to be turned from it immediately to one side at right angles, and its diminution of Velocity would be intermediate if it passed from the right line in an acute angle, the same holds good with the Velocity of the Blood, and the angles formed by the Arteries.

Convolution of the Vessels is another circumstance affecting the circulation of the Blood, and it is generally found in those parts where a slow circulation of the blood is required, as in the Brain. The more convoluted a Vessel is, the slower must be the circulation through it, for the

convolutions act much in the same way as the Angles do. This structure is very remarkable in the Spermatic chord of a Horse. It operates in retarding the circulation in two ways, first by increasing the resistance, & secondly by adding to the distance from the Heart. Collateral Vessels passing off from the trunk of an Artery by lessening the Volume diminish the Velocity of the blood. It has been a question how far the nervous influence affected the circulation. Some suppose a great deal and adduce the state of a Paralytic Limb in support of this opinion. They say they have a slow circulation and are weak, the muscles being emaciated & pale.

This however if examined closely will not prove so strong an argument as might at first appear, for all these symptoms may be found in cases where there is no interruption to the nervous influence, as in diseases of the Joints. The Palsy prevents the action of the limb, & the Muscles being inactive has not in consequence that quantity of blood determined to them that otherwise would be.

Under these circumstances they waste, become flaccid and a less quantity of blood being necessary to supply a small than a large limb, the Arteries become small & weak & this reason applies equally to the Paralytic Limb, or limb with diseased joint. If we observe this change in the circulation in a recent Paralysis such a one for instance, as is produced

by dividing the Nerves for the purpose the before mentioned opinion would be entitled to our credit, but we shall find that at first the action of the Artery is not at all diminished and it becomes weaker gradually as the limb emaciates. It is a law in the Muscular Economy that they increase when much in action and diminish when they remain long inactive, not only because when they are in action they require a greater supply of blood, but the alternate contractions & relaxations of the fibres impel the blood forward and so increase the circulation.

Thus we see that the fact adduced in favour of the nervous influence affecting the circulation is not much to be relied on. (If also we have recourse to experiment they tend to prove that the nervous influence has not much affect here.)

I laid bare the Sciatic nerve of a Hog, and put its foot under a microscope and then irritated the nerve by pinching it, but a person observing the circulation through the Microscope could not tell when the nerve was stimulated and when not. Again if the nerve be divided and a wound is made in the Paralytic Limb, it will heal quite as well as in another. I divided all the nerves I could find going to the hinder leg of a Hog, the Sciatic as it passed out at the great notch, the obturator as it passed out of the Foramen, & the Crural as it passed out of the Pelvis, so that the limb was completely paralytic except a few Muscles at the top of the

Thigh which were supplied by branches sent out by the Crural previous to its passing out of the Pelvis.

I then divided the *Tendo Achillis* in both legs. When the dog began to walk about the limb that was Paralytic knocked against the ground, so that the integuments became ulcerated and the Os Calcis sloughed off. Being at this time ill I could not look after the dog, but what I wished to prove turned out perhaps better than it otherwise would have done, having nothing to attach itself to, but it increased to three or four times its usual thickness. This proves that the nervous influence has very little effect on the action of the Arteries, but I do not say that it has none at all. It has been observed that the motion of the blood in the Arteries is not uniform but by saltations, the Arterial being alternately in a state of Systole and Diastole or dilatation more strictly speaking, that forms the pulse and when that is great we have a full slow pulse, when small, a quick and contracted one. Under inflammation the Capillaries partake of this motion from being then more dilated, and hence the throbbing sensation at that time.

If the Artery is impatient of contraction it gives a hard pulse, if still more impatient a quick one.

The pulsation of the Arteries in different parts of the

body, are the same in number but not in time. This is observed in feeling it in the hand and foot at the same time.

The natural frequency of the pulse is depending on the size of the Animal. In the human subject, this differs at different periods of life. Sometimes the regularity is disturbed and every now and then a pulsation is wanting, this is called an intermittent pulse. It is generally thought a bad symptom, but that depends entirely on the cause of it.

If for instance, it happens in Dyspepsia, Hysteria, Hypochondriasis, it is not very material. The late Dr. Monsey of Chelsea, had through his life an intermitting Pulse, till within a year or two of his death, and he lived to the age of ninety six. Hence there are exceptions to the circumstances of an intermitting pulse being dangerous, though we are to consider it such when it proceeds from disease.

Sometimes this pulse is depending on the ossification of some part of the Heart and Arteries, in which state not being able to contract towards their Axis so as to propel the blood, a part regurgitates and gives rise to the intermission. Other Symptoms attend these ossifications by which they may be known.

There are means for increasing or diminishing the action of the pulse. Exercise hastens the return of the blood, and if the Heart is healthy it then acts quicker. Food and many medicines quicken the pulse. Much has been said lately

about Opium, which is said to be universally a stimulant.

But when it produces the following effect I must consider it as a Sedative. I injected into the circulation of a dog Twenty drops of Tincture of Opium in one drachm of water.

The Pulse was brought down from 140 to 120 and gradually down to 60 in a few minutes. The injection often did not produce so great an effect. When the same dose is taken by the mouth, the pulse is not affected in an hour; when injected in a much less time. - I consider it entirely as a Stimulant or Sedative, in proportion to the dose which may be given. - - - - -

Lecture 20th

Of the Venous Circulation.

The Blood after circulating through the body by means of the Arteries is again brought back to the Heart by other Vessels. These are easily distinguished from Arteries at an amputated extremity being collapsed, while the latter retain their circulated form. They are evidently larger than Arteries, though when collapsed they appear smaller. This arises from difference of structure, Arteries being more muscular and having an

internal elastic coat which Veins have not. From the sides of Veins arise valves which are formed by a doubling of their internal coat, and which allow the blood only to pass in one direction.

The Veins generally correspond in number with the Arteries, and take the same course particularly on the Viscera, and the only difference between them is that the Veins are larger.

In some parts however we do not find them to correspond, but there are two or more Veins to an Artery, and these two Vessels are separately larger than one Artery, so that there is a difference as to number and size, and consequently the circulation must be slower than if they corresponded, this happens externally. The Veins like the Arteries have free communication by Anastomosis, but the Vessels of communication in the former are larger than those in the latter, so that the circulation will not readily be impeded in them if pressure be applied. Veins are of two orders Viz: superficial and deep seated. The latter follow the course of the Arteries and have a free communication with the superficial Veins, and therefore if these be compressed, the deep seated ones will be found to return the blood. We observed in a former Lecture, that the circulation of the Arterial blood was performed by saltations, but in the Veins it is uniform and gradual without any pulsation, for as the Veins arise from the Capillary Arteries, which are at a great distance from the Heart, and possessed of very little muscular power, no pulsation

is felt in them. In some Veins however lying near the Arteries or the Heart, as the Jugular, an apparent pulsation is seen corresponding with that of the Heart. But this does not arise from any power inherent in the Veins themselves, the blood being interrupted by the contraction of the Heart the pulsatory motion is extended to the neighbouring Veins. The blood does not move gradually through the Veins in every part alike.

Different positions retard or facilitate its motion, & in the Viscera it is more rapid than it is externally. What is the office of the Valves? Hitherto it has been little understood, we should first enquire where Valves are to be found.

In the Pancreas, Spleen, Liver, and other Viscera of the Thorax and Abdomen there are none but in the extremities, which in the Viscera are not necessary. Some have said their use was to resist the effects of pressure on various parts, and to obviate any impediment to the return of the blood to the Heart. Veins have some little muscularity and a power of adapting their size to the fluids contained in them.

This muscular power may assist in propelling the blood forward. In some persons especially about the middle period of life the Veins are sometimes very much enlarged, producing what is called varicose swelling in them. It arises from debility and may be much relieved by bandage, cold bathing &c. Another cause which retards the circulation through the Veins

is want of exercise. People therefore who live a sedentary life, and whose muscles in consequence are kept inactive are much more liable to varicose swellings and Oedematous legs.

It is from this principle that the legs of Horses swell from standing in the stable without being exercised, for the blood having to ascend, and being deprived of any assistance from the Muscles and Tendons is not able to get forwards and a swelling is the consequence.

We are now to enquire in what manner Oedema is produced. If any thing retards the circulation of the Venous blood, as debility in the part, from want of exercise or from any other cause, as pressure on the trunk of the vein &c. a resistance is given to the blood in the Capillary Arteries, and their action is in consequence increased as is also that of the exhalents arising from them.

In consequence of this excitement of the exhalents an aqueous fluid is effused, producing Oedema when partial or Anasarca when general. That this is the case is evident upon experiment. If pressure be made on the principal vein of a part, the contiguous vessels are at first inadequate to return the additional quantity of blood, and a swelling is the consequence, but as the veins will become gradually enlarged, the Oedema will also disappear. Thus we may account for Dropsy of

particular parts, being produced by pressure from large Tumours, as enlarged Glands, as all the Veins arising from the Abdominal Viscera and Peritoneum terminate in one common Vein, the Vena Portarum; what must be the consequence of a Sclirous Liver.

The circulation must be retarded in the Vessels of the Viscera, and water must be effused into the cavity of the Peritoneum from the increased excitement that is produced in the exhalents producing Ascites. But Anasarca arises from another cause. Any thing as Hydrops Pectoris impeding the action of the Lungs and the circulation through the Superior and Inferior Cava will produce Anasarca.

The blood must pass through the Lungs before it is distributed to the other parts of the body, and it follows of course that impediments to their functions must obstruct their circulation and water will in consequence be effused and produce universal Anasarca. Hence it is evident in cases of dropsy from a Sclirous Liver or from impeded respiration, Diuretics can be of no service. In one case of Anasarca, proceeding from Peripneumony, small bleedings were successfully employed tracing up the disease to an inflammatory affection. It seems a law in the Animal Economy that there should be a different balance in the circulation at different periods of life, which

gives rise to a variation of colour in youth & old age.

In the former the complexion is more florid, & in the latter more of a purple hue. This arises from the Arteries in youth being more pervious and the Veins less so than in old age. But in what does that difference in the balance of circulation depend? It appears to me to arise from an alteration in the structure of the Veins.

In youth they make a greater resistance to the Arterial blood, but in old age they seem to have lost this power.

This which has been hitherto a mere matter of opinion, seems now to be determined by experiment.

Sir Clifton Winkingham, laid bare a Vein, and applied a considerable weight untill it burst.

This experiment was made upon both Old & Young subjects, and in the former he found it to burst much sooner than in the latter.

Hence it is that old people have varicose and ulcerated legs which prove so obstinate to heal, but by giving a due degree of tone to the Veins by dashing cold water on them, using friction &c, they will sometimes be recovered from their debility.

Lecture 21st Of Respiration.

The Blood we observed is a fluid of very great importance to Life; we have taken a general view of its constituent parts, & shall now further consider the changes it undergoes in the course of circulation. The colour of the Blood in the large Arteries is very florid, in the small Capillaries is less so, & in the large Veins near the Heart almost approaching to black. When blood loses its florid colour and becomes purple, it is then rendered unfit for the purposes of Life. A change therefore is produced on it in its passage through the Lungs, by which it is restored to its former healthy state.

It is not merely in consequence of the blood passing through the Lungs that this change is effected, but it is brought about by the peculiar action of the Lungs, viz. Respiration. The Lungs take in Air which they retain for a few seconds, and then expel it, & then receive another supply, and so on alternately, which alternate action constitutes Respiration. In order to understand the Economy of the Lungs in producing a change in the blood, we must first premise some general facts.

The Lungs are two in number, one situated on the right side of the Chest, and the other on the left, hence are called left and right Lung. They are composed of two parts, viz. Air cells and blood vessels,

and that the latter are of two kinds, ramifications of the Pulmonary Artery and Veins. The cellular portion is by much the largest. In the human subject the cells are not larger than pins heads, in many other Animals they are much larger. The Bronchial branches of the Lungs appear to be nourished by the Bronchial Arteries, & the other branches chiefly by the Pulmonary Artery. The Lungs are situated in a bag called the Pleura which lines the whole cavity of the Chest and separates one Lung from the other, by forming a doubling or Mediastinum, so that the action or function of one Lung may be impeded by certain circumstances without the other being affected. The Pleura not only forms a bag but also a close covering to the Lungs being in a very small degree porous prevents the Air from pervading or diffusing itself into the cavity of the Chest. The Lungs have free motion in the chest, except at the root where they are fixed and where the Vessels and the Bronchial enter their substance.

This however is not the case in all Animals. In Birds the Lungs are fixed to the sides of the Chest and Spine. These also have no Diaphragm and therefore it seems there is some difference in the manner in which Respiration is performed, mobility not being necessary to this class of Animals. Galen and some other Physiologists have said that Air was not only included in the Cells of the Lungs but in the Pleura also, & this they endeavoured to prove by experiment. They asserted that if an opening was made into the cavity of the Chest, and a bladder applied to the aperture of

it, it became distended with Air. Now it seems they were not aware of the fallacy of that experiment, which is very great, for if an opening be made the Air immediately rushes in, which during the act of inspiration is again expelled and hence the bladder becomes filled. Harvey a much later writer was also of this opinion.

It has been further said in proof of this Hypothesis, that if an Animal be immersed under water and an opening made between the ribs Air will rush out and occasion bubbles in the Water; but in this instance there must have been a deception, for the Air which occasions the bubbles proceeds from the Lungs, in consequence of their being wounded in making the experiment.

Those who contend for the existence of Air in the cavity of the Thorax assigned as a use for it, that it reacted & pressed upon the Lungs when expanded to expel the Air which had been taken in by the Trachea. But upon accurate experiment and examination no such air has been discovered consequently the assertion is unfounded.

The Lungs perform two actions Inspiration and Expiration. Inspiration consists in receiving Air into the Cells of the Lungs, and Expiration in emitting it after it has been received, and has undergone its changes. Some have very unphysiologically argued that the pulsation of the Pulmonary Artery distended the Lungs, & caused inspiration. Hollen supposed the Lungs had the power of action in themselves. But if this was the

case Respiration would go on when the cavities is opened which is not the case. It seems then that the Lungs are passive organs and that the Air is not drawn into them by a power of the organs themselves. We should examine the structure of the Chest and consider the action of the muscles & mobility of the Ribs which are causes of enlargement of the Chest.

The Diaphragm materially assists in this action, as also the intercostal muscles. The Ribs have different degrees of motion it being more extensive as they descend, and hence each superior Rib acts as a fixed point, for the action of the muscles thus are elevated. It appears therefore that the office of these muscles is to enlarge the chest. Suppose then a ligature is made on the Trachea the vacuum in this state is immediately filled up by the Air rushing in and expanding the Lungs as soon as the ligature is removed. (Thus it is that inspiration is performed.) Thus Respiration is performed by one or other of these powers though one is more immediately concerned than the other.

For instance, after a full meal the Diaphragm is rendered incapable of descending from the distention of the Stomach, so that the intercostal muscles become the principal organs in action. The same occurs with respect to the Diaphragm in dropsical People, and in women also who lace tight.

At other times the Diaphragm is the principal organ in action as in the case when bandages are applied to fractured

Ribs. After Inspiration is performed the next action is Expiration.

The connection of the Ribs with the Sternum being very Elastic and assisted by the action of the Abdominal muscles the Ribs are brought down, and at the same time the Viscera reach and press upon the Diaphragm which narrows the cavity of the Chest in two directions. That this is the case is not only creditable from reasoning but from the action of the muscles themselves which is perceptible to our senses.

That this action depends on some nervous energy cannot be doubted, for if a nerve going to a muscle be compressed or divided, that muscle loses its action. The Diaphragm loses its power also by pressure being made on the Phrenic nerve, but if any accident happens to the Spinal Marrow below the origin of this nerve the action of the Diaphragm does not cease. The actions of the body are such as depend upon the Will, and such as are performed without our being conscious of them; hence the division into Voluntary and Involuntary actions. Respiration partakes of both these and is called a mixed action? What are the purposes answered by Respiration? Physiologists say there are two, one is a free passage of the Blood from one side of the Heart to the other, but this is casual and not essential.

We have said that the Lungs are composed of Cells and Blood vessels, and that the former are alternately distended and

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Collapsed. It must follow that the freedom of circulation is affected and the diameter of the vessels diminished during Respiration. Sauvages asserted that the Lungs were ten times larger during Inspiration than Expiration, but if this assertion was true the Lungs would not be contained in the Chest. It is evident however that the size of the Lungs varies very considerably during these two actions; that the branches of the Pulmonary Artery contain a greater or less quantity of blood in consequence.

Dr Goodwin wished to make it appear that the Lungs were of the same size in both states. This he attempted by examining how much air was taken in at each Inspiration, and also how much remained after so much Expiration, and he says there is little difference, but his experiments are fallacious. He contends that only two or three cubit inches are taken, but I found that fourteen or fifteen were taken in at each Inspiration. It is to be remembered that about twenty eight cubit inches are equal to a pint of air, and the heat existing in the Lungs about double the bulk, and hence about a pint of air, is taken in at each Inspiration. The next and most important purpose of Respiration is the change which is produced in the Blood in its circulation through the Lungs. — —

LECTURE 22ndOf the change induced on the Blood
in its transmission through the Lungs.

WE ARE now to consider the change which the blood undergoes in its transmission through the Lungs, it being very different as to colour previous to its entering these organs to what it is after having passed through them. In the first instance it is of a purple colour, and afterwards becomes of a florid red. But it will not be amiss to give a general historical view of this subject as by that means we shall better understand the gradual changes and improvements on it. Physiologists and experimental enquirers of the last century were perfectly aware that a continual removal of Air was necessary to produce this change, and they made many experiments to ascertain how it was affected.

Mayow and Boyle agreed that a certain portion of Air was lost, and Dr Hales says that there is lost about half, and that this was absorbed. But if this is the case the presence of Air does not manifest itself in the blood and must therefore be in a most intimate state of chemical combination. Experiments made with the Air pump have fairly proved

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this. Some have said that the elastic part of the Air was absorbed, and that where this was lost death ensued.

But as Chemistry was at that time in a very imperfect state, we cannot expect much accuracy on that point.

This was the opinion of Boyle and Mayow who put Animals in jars of Air, and finding it became diminished in quantity conceived it to depend on the loss of Elasticity.

Other experiments were also made to ascertain the effects of Air on the process of combustion, where also it was found that Air lost one of its properties and underwent a diminution of its bulk. Hence it was considered that the process of combustion and Respiration were analagous, and instead of calling the matter given out *Toot* as in combustion they gave it the name of *Muliginous matter*. About the middle of the last century a repetition of Vesalius's experiments was made by Hook.

He opened the chest of a dog and made an opening also into the Trachea, to which he fixed a pair of bellows so that he could distend the Lungs, and by alternately distending them and suspending their actions he got a clear conception of the manner in which Respiration was performed. He found also by experiment that the action of the Heart corresponded with that of the Lungs.

It was likewise about this time that the change which

the blood undergoes was first speculated upon.

LOWE endeavoured to investigate the cause, and knowing that a solution of Nitre added to Venous blood, rendered it of a florid red colour, he then considered the change to be in consequence of nitrous Acid Gas, received into the Lungs and imparted to the blood. This conclusion was natural enough, and though modern discoveries have found it to be owing to the pure Air given out in the decomposition of Nitre. Experimental Physiologists also discovered that a kind of Sooty matter was evolved in the process of combustion, and conceived that something of this kind was in like manner given out in Respiration; this they speak of very largely in their works. Now it was that the celebrated doctrines of Stahl made their appearance, which suppose a principle of Phlogiston or inflammation in certain bodies. This theory was made use of by Physiologists to explain the change made by the Lungs on the Venous blood. It has however been critically examined by Dr. Priestley, for which purpose he made a great number of experiments on blood with different kinds of air. He found that by putting Venous blood into a jar of Phlogisticated Air or Azot no change was produced, but by putting it into

common Air, it changed its colour to a florid red.

This he attributed to the Phlogistic principle. Dr. Priestly was well aware that blood and Air in the Lungs are not in actual contact; blood vessels being interposed. He therefore interposed between the Air and the blood pieces of membranous substance, when the blood underwent a similar change, and thus performed the result of his experiments to coincide with what took place in the Lungs. These experiments although very ingenious were not altogether correct, as the coats of the vessels are different from membranes, and if a principle of Phlogiston be evolved, it is from the extremities of vessels and not from their sides.

We are now since the discoveries of Lavoisier, pretty pretty well acquainted with the constituent parts of Air, but though Philosophers agree in this, they do not in the exact proportion of each part. They all agree likewise that there is some part of the Air not essential to life, and it is that part the Alchemists called Phlogistical Air, or Azote by the French. The atmosphere it seems then is composed of three parts, of Phlogisticated Air, of Pure Air, or dephlogisticated, and some have said of a small quantity of Orial, Carbonic or fixed Air. It becomes therefore necessary to examine the Air previous to any experiments being made, for these will vary in proportion to the degree of

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the purity of the Air. Dr. Goodwin asserts that Respiration increases, the proportion of fixed Air, that on Inspiring a hundred parts of the Atmosphere, he found that it contained eighty Phlogisticated, eighteen of Pure, and two parts of fixed Air, that on retaining it in the Lungs as long as possible the fixed Air increased to thirteen parts, and the pure decreased to five, the Phlogisticated Air remained unchanged, so that it seems this last serves only as a medium for the two others. I found by experiment nearly the same result. Some have said that fixed Air was resident in the blood, and that this was evolved while the pure Air was absorbed, but those who reason thus appear not to have a competent knowledge of the properties of the Air, for fixed Air contains a portion of pure Air, and a carbonaceous principle, and it is this principle only that exists in the blood, which uniting with other properties forms fixed Air. Dr. Goodwin contended that fixed Air was not destructive to Life, and that the ill consequences arising from Air being too long retained in one place proceeding from a diminution of its purity, in other words it was the want of pure, rather than the presence of fixed Air, that proved destructive, but I can refute these Arguments by actual experiments. By suspending Animals for a short time in fixed Air life was destroyed,

and it will even extend its deleterious effects to those Animals which inspire in water. If Water be impregnated with it, and although combined with pure Air it will yet destroy life. In order to make the change in the blood and Air as conspicuous as possible I made many experiments. I first opened the Chest and Trachea of a Dog and fixed it to an elastic bottle which contained the common Atmospheric Air and forced it into the Lungs.

The result of this experiment was, that the blood coming from the Lungs was of a florid colour.

I made the experiment a second time with pure Air, when I found the blood remain rather of a deeper purple than it was previous to its entering the Lungs. A third time I repeated the experiment with that kind of Air that will extinguish flame, and found the result of this to be similar to the first, so that it seems there is something separated or evolved from the Mass of blood which is deleterious to life, and is that which the Philosophers of the present day call the carbonaceous principle. In an experiment made by Dr. Hunter for another purpose where he conveyed the blood from the carotid of one Dog to the Jugular of another, he observed the blood to be more florid, as it flowed from an Artery opened in the Leg, and reasoning upon it discovered it was owing

to its being doubly oxygenated. That is, after having passed through the Lungs of one dog it was taken immediately from the Carotid and conveyed to the Jugular through the Lungs of the other before it had acquired the carbonaceous principle. Some animals are capable of supporting life in bad Air longer than others, and this arises from a variety in the structure of the Lungs. Those animals as Frogs, besides Air Cells have a kind of bag that answers for a receptacle of Air, can while Respiration is carried on by the Cells live a long time without Air; but man and other quadrupeds have Cells only and those very small cannot.

The Otter and Whale cannot truly be said to be amphibious Animals, for although capable of remaining a long time under Water, they are frequently obliged to come up to the surface to take in fresh Air. In these Animals also a part of the blood only, passes through the Lungs at each circulation.

Lecture 23^d

Source of Animal Heat.

Besides changing the colour we are now to consider what other office is performed by the Respiratory organs.

We have many facts to prove they give heat to the body, &c.

hence we speak of them as the source of animal Heat.

We are now to consider how far the circumstances we last mentioned are the source of animal Heat. It is first necessary to consider what heat is, and to have some precise Idea of it. Some have said it is matter, others that it is only a property of matter, but as the Philosophers of the present day consider it to be matter we shall here speak of it as such.

We know that beating two pieces of Iron together will produce heat, but this only proves the Mechanical production of it. Chemists on an extensive view of the subject look upon heat as an elementary matter entering into the composition of all bodies either in a sensible or latent form.

We must be precise in our definition of Heat. In common language we mean anything that when touched gives the sensation of Heat, but we must not express the same term for cause and effect. When we name Heat we mean by it the matter of heat, and when we speak of temperature we mean by it sensible Heat. Heat does not always express its presence either to the Thermometer or touch, as is evident from the mixture of Vitriolic Acid and Water, here it prevails in a latent form, and therefore we are not to judge of the principle of Heat as being absent because it does not manifest itself to our senses. No one could a priori say that Carbonic Acid Gas was contained in chalk, yet by adding the Sulphuric Acid

to it the former is set loose in a sensible form. The mixture of snow and water with Sal. Ammon. does not generate cold although it gives the sensation to the touch of the finger. It is robbing the finger and all surrounding bodies of their heat, so as to obtain their temperature. All bodies we know by Chemistry are not disposed to combine with each other, Heat will more readily combine with one body than another, and hence arose the doctrine of Elective attraction.

Dr. Crawford has made many experiments to ascertain what these bodies are. We do not however intend to enter minutely into this subject but so far only as it illustrates the point in question. The air thrown out of the Lungs has less heat in combination than that taken in. Why? Because the air expired is loaded with carbonaceous principle which contains but little, but the contrary holds with regard to the oxygenous part of the Air inspired. This is a process of double Elective attraction which may be best illustrated by a kind of diagram. We have observed that there is a difference in Arterial and Venous blood, that the latter contains more of the Carbonaceous principle, & has a less attraction of the matter of Heat. Pure Air always contains a large quantity of Heat in a latent form not sensible to the Thermometer, and has a much greater attraction for it than fixed Air, as is illustrated in the Theory of combustion. The blood

in the Pulmonary Artery is Venous and contains the Carbonic principle, but in passing through these organs it loses this principle, and unites with the oxygenating or Acidifying principle, which with Heat are the two properties of pure Air. The consequence of this separation of Heat from the pure Air by extrication of Oxygen, and blood after being deprived of its Carbonaceous principle has a greater attraction for Heat. Thus it is that the Arterial blood attracts the Heat and communicates it to the body.

But although this circumstance occurs, blood is not increased in temperature after passing through the Lungs, but on the contrary is diminished about two degrees.

Some have thought proper to quibble at this and have said how can the Lungs be the source of animal Heat, if the blood passing through them is diminished in temperature. The reason is that the heat is present in a latent form. The blood containing latent heat in passing through the Vessels receives the Carbonaceous principle. This extricates the heat existing in the blood and it is communicated to the solids in a sensible form, by a kind of decomposition, and hence the degree of heat will be in proportion to that of the Carbonaceous principle. From the proceeding facts we might suppose that in proportion to the quantity of blood passing through

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a part would be the degree of heat, but this may not be the case, for in passing too rapidly it may not be decomposed, & that heat does not depend on the quantity of blood, but in the degree of decomposition is evident from observing the effects which succeed to the operation for Popliteal Aneurism. After this operation the Leg becomes warmer and the reason is that the principal Vessels being destroyed the blood circulates through collateral branches and consequently much slower than usual. It becomes also a deeper colour from a greater proportion of Carbonaceous principle being generated by this slow circulation, and by which means heat is given out in a sensible form.

In a Man the Respiratory Functions were suspended for a minute and a half, and they had before been very much impeded; his body in consequence was very cold, and his face of a dark purple colour, but on admission of Air through the Trachea, the face became more florid, and the heat of the body was soon sensibly increased.

Again in another case a Woman had an obstruction of the Larynx. She always felt cold, and on introducing the Thermometer under her tongue, I found her temperature four degrees below the usual standard.

In an experiment made for another purpose on a dog, the Lungs were deprived of their nervous energy, and the

Dog was evidently much lower than natural. I found the degree of heat was always increased by the action of these organs. And hence there seems to be an agreement between the extent of the Respiratory organs and the degree of heat in different Animals. Those Animals that have small Lungs and breathe little generate but little heat; this I proved by experiment. I procured Animals such as Frogs, Snails, Eels, Leeches &c, whose Lungs vary in structure, and examined their relative heat, and I found the difference to be in proportion as the structure of their Respiratory organs varied. The Heat of the human body is the same in Winter and Summer, in an inhabitant of the torrid regions as in one of this Climate; Dr Crawford has made some experiments to explain this, by immersing Animals in cold and warm water.

He found Animals in a cold medium generated more of the Carbonaceous principle than in a warm one.

On this too we explain the blueness of the fractures in frosty weather, more Carbon being then generated.

Now this Carbon decomposed more of the Air in the Lungs, and this in proportion to its quantity, and hence heat is obtained according to the necessity, and an uniformity of the temperature in the Animals inhaling different regions is thus kept up. The Air therefore gives out heat

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in proportion to the necessity and the medium to which the Animal is in. It has been Anatomically discovered that a mal-conformation of the Heart, as when the Aorta and Pulmonary Artery arise from the same cavity, diminishes the Heat of the body, for a part only of the blood can then circulate through the Lungs. The same effect is produced in Phthisis Pulmonalis. The Lungs in this disease are much affected and the transmission through them is in consequence imperfect. The blood by this means is only partially decomposed, and hence arises that chillness which Patients labouring under this disease experience. (Vide case by Mr. Abernethy.)

Lecture 24th On Suspended Respiration.

It was observed in a former Lecture that a slow circulation was favourable to the generation of the Carbonaceous principle, that the Carbonated blood was carried to the Lungs where it underwent a double decomposition. That the Carbonic principle was here evolved, and combining with the base of the Oxygen was expired in the form of fixed Air, and at the same time

Caloric being set loose from the Oxygen, and the blood having lost its Carbon, acquired a disposition to unite with the Caloric. But it was stated also that the blood notwithstanding this was two degrees colder than before in the Lungs, nevertheless it contained more latent heat and its circulation through the small vessels of the body, meeting with Carbonaceous principle, the latent heat was set loose in a sensible form, giving rise to the Animal heat. If from any cause the evolution of this Carbonaceous principle be prevented, the Animal machine must be greatly injured. This leads us to consider the cause of death from hanging, drowning and suffocation; and first with respect to hanging. Various have been the opinions formed on this subject; Some have supposed the neck to be dislocated, and that death was the consequence of the compression of the Spinal marrow. But upon enquiry some doubts arise respecting this as being the cause, for dislocation does not always happen, and provided it did death would not take place sooner than it generally does. It may however occur in some instances particularly in corpulent men. Finding then that this opinion did not stand the test of enquiry another idea arose, viz, that Apoplexy was the cause. There are some appearances which argue strongly in favour of this. The appearances of Apoplectic & Executed subjects are somewhat similar. In both the face is bloated and of a purple colour. indicating a great accumulation of blood in the head, & this

perhaps chiefly Venous blood from compression on the Jugular Veins.

But notwithstanding these appearances further investigation gives rise to some doubts and leads us to suspect whether some cause may not be combined with Apoplexy if this exist at all.

I have examined the Brain of many executed subjects, and always found the Veins turgid but without any extravasation, Mr. Utium who has examined many, found the same. Now how does this accord with the appearances of those who have died Apoplectic.

In the latter extravasation has always been found & sometimes in large quantities making great pressure on the Brain, but still the patient has lived some days. Now then are we to explain this difference? Some other agent must be called in. It has been said by some that Apoplexy has not been connected with hanging, but that death is the consequence of suspended Respiration entirely.

An experiment has been made which puts this beyond all controversy. The Trachea of a dog was opened by Dr. Monro, & a ligature being passed above the aperture he was hanged. But death did not ensue, but on applying it below the opening, death was the immediate consequence. Hence it would seem that pressure of the Vessels is not sufficient to produce death, although it is made on the Trachea, and I have found, this part often much bruised. I am of opinion that this experiment is clear and decisive, though I admit that some objections might be made from the difference of circulation in the dog and Man.

In the human subject the blood is easily obstructed in its return from the Brain by the Veins while it is still going there by the Arteries, so that great accumulation must be the consequence.

Now the Jugular Veins of Dogs, they have but little to do in the return of blood, and although those may be compressed death will not follow, the Vertebral Artery and Vein being in them sufficient to support life, and their Brain is also in proportion much smaller than the human. When we examine the interior parts of executed subjects, we find an accumulation in the Pulmonary Artery, and right side of the Heart, for the pressure on the Trachea preventing the reception of Air, while the Muscles are still continuing to act every portion which pre-existed in the Lungs is expelled, and hence they become collapsed, so that the circulation through the Heart is impeded. These Phenomina occurred in other modes of death when Respiration has first ceased.

We now proceed to some remarks how death is produced in drowning. Some have supposed that death in consequence of submersion was caused by water taken into the Lungs, but it is not generally occasioned to be from water getting into the Lungs.

When thus received it excites a distress in those organs, & they become convulsed to expel it, and hence we find on examining the Lungs of Animals that have died from submersion a small quantity of water and that frothy; Haller first remarked this.

To prove that this water is not taken in by mechanical pressure

but by mere action of the Respiratory organs many experiments have been made. Dogs have been immersed in different coloured Waters and the result of this has been that a quantity of it has been found in the Chest. Similar effects were also produced by drowning a Dog by the legs with his head under water, and in this case it could not descend from its own gravity, & further to evince this, immersing a dead Dog no water was found in the Lungs, nor is any water found in the Lungs of a *Fetus* the Respiratory organs in them not being in action.

Another opinion has been that it was not the water that occasioned the death of the Animal, but to the obstruction given to the reception of Atmospheric Air into the Lungs.

I made an experiment which seems to confirm this idea, for injecting water into the Lungs of a Cat, by means of an aperture into the Trachea I found that the Animal lived, and by repeated convulsive efforts converted the water into the form of Vapour and expelled it. I also opened the Trachea of a Dog and with a Syringe injected 3ij of fluid into the Chest.

The Dog had symptoms of Dyspnoea, in a few minutes he became calmer, and soon after his breathing was as free as before. Hence a small animal took two ounces, an Adult being six times as large might take twelve ounces, but so much is never taken in, and of itself cannot cause death. This water is taken into the Lungs by the Respiratory Muscles, the Expiratory

muscles throwing out Air, and a small quantity of water which gets in at each action of the Inspiratory organs.

It therefore seems that it is not the water that destroys, but the absence of Respirable Air. The appearance of the Brain is the same as in other Animals, only that there seems to be a scarcity of blood, instead of the Vessels being turgid; and this strongly militates against the idea of Apoplexy, being the consequence of Drowning. Similar effects are produced on the Heart and Lungs as from Hanging.

Lastly, the consideration of death being produced by noxious vapour comes under our notice. If an Animal be suspended in fixed Air from whatever source it may arise, either from lime mixed with Vitriolic Acid, the fumes of Charcoal, effluvia from wells, or fermentable matter, death is the consequence. It seems here that death is produced by the absence of Respirable Air, and by the irritability of the Animal being destroyed. Now if we take a view of the causes of death, we see appearances of each quite different, and no solution of the Carbonaceous principle is carried on in either. Let us consider next the means to be used for restoring life under suspended Respiration. This is to be effected by distending the Lungs with Air, and exciting the Heart and Arteries to action. There are various means of doing this; a common pair of bellows is often used, but if pressure be not made on the

Trachea, the Air will pass into the Stomach & not only deceive us in that respect, but it may do much mischief there and prevent the descent of the Diaphragm; for the particular mode of performing this, (vide) Mr Coleman's treatise on suspended Respiration, where this subject is treated in a very masterly and accurate manner, Mr Coleman's operation is very simple. An elastic tube to pass down the Oesophagus, by which fluids may be conveyed into the Stomach by means of a Syringe, curved tubes to be passed into the Trachea by which the Chest may be filled by a common pair of bellows, and a knife to perform Bronchotomy, and to introduce a pipe to inflate the Lungs that way. At the time the Lungs are distended, an elastic shock may be sent through the Heart to excite it to action, but this should never be done in a collapsed state of these organs. If after the electric shock the action of the Heart can be felt it is favourable, though the artificial respiration should not be withdrawn too quickly, observing first whether the Respiratory organs are able to carry on their action and to what degree, and we may then assist it by proper means which are different as friction &c. But even in this it would be injudicious to use it in the first instance from the right side of the Heart being before distended. It is on this account that some people have proposed bleeding, but as we cannot take blood immediately from the Heart, I think it had better be omitted except in cases of suspension where

opening the Jugular Vein may relieve the accumulation on the head and this should be little or it will debilitate too much.

A little Brandy or other Stimulus may be now exhibited, and a Stimulate injection thrown up the Rectum. Some authors have spoken a great deal of the expediency of heat, I think this may be very necessary, but it is not what first should excite our attention. External stimuli of every kind are useless if the Respiratory organs be not put in action, and they may be even injurious by promoting the return of Venous blood and thus adding to the burden of the Heart which has already too much to act upon. But after this action is established, simple friction may be necessary & serviceable by supplying its right side with blood. The body may be placed near the fire, and Cloaths dipped in warm water be applied to it. Some have conceived Emetics to be useful, but I think them by no means so, and as their first effect is to nurseate they tend rather to depress life. If they could be administered as pure stimulants benefit might arise from their exhibition. Tobacco James ought to be avoided as deleterious, and though they may assist in some instances, the restoration of life is not to be attributed to them, and I have seen very great danger arise from their use. In a collapsed state of the Lungs, Electricity should not be used, for at that time the blood cannot pass, and you excite the Heart to no purpose.

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without its having blood to act upon. The shocks also should be weak, and some have said they should be passed in the oblique direction of the Heart. -----

LECTURE 25th

On the Economy of the Brain.

The Brain is that organ of the body which is the Source of Sensation. Quadrupeds, Birds, &c have Brain and Nerves, and are consequently endowed with sensation.

We do not annex any peculiar Ideas to the Brain, for any part having nerves passing from it might be considered as the common Sensorium. The bulk of the Brain varies in different Animals. Large Animals have sometimes a small Brain; and in general the more complicated and perfect Animals are, the larger the Brain.

The Brain of a man and many Animals, bear much resemblance to each other, but as we descend this resemblance is lost. In the Leech the Brain is of an annular form like a ring from which filaments pass, and the Oesophagus is seen also to pass through it.

There is a great variety in the figure of the Brain in different Animals, as also in its situation. It may be asked

if in any Animal it is situated any where but in the head?

In the Snail it is situated in the upper part of the neck; sending off numerous filaments which are Nerves.

Some Animals have Brain, and though the *Fetus* has, yet it is not essential to life before birth. The general order of nature is, that where there is a Heart, there is also Brain.

And hence it would seem, there was a connection between these organs. This is certainly the case for was there no circulation, there would be no Brain. The *Polypus* having no Heart, has no Brain, and consequently no sensation.

The existence of these organs seem natural as the Brain receives blood from the Heart and imparts it to the nervous energy. A *Fetus* may have a Heart and Vascular System without a Brain, though it has spinal Marrow. In the *Uterus* the Heart acted, but when such Monsters are born, the Heart having to support the Animal by its action soon dies. A large portion of the blood is sent to the Brain, and some have endeavoured to estimate its quantity. The Vessels carrying it are the two Carotids and Vertebral Arteries, and from having measured the diameter of these Vessels it has been said that one third of the blood of the body circulated through this part.

But this is wrong a large quantity in proportion to its bulk is certainly sent into it, but I think this is not more than

one fifth of the whole. Sometimes the blood may not go on in such quantities to the brain from pressure being made on the external Carotids, but this does not appear to disturb the functions of the Brain from the general communication between the Arteries on the Sella Turcica of the Sphenoid bone where the circulus Arteriosus is formed.

I have tied the Carotids in Dogs and no ill consequence has followed. In this case the other Arteries cannot enlarge, nor does this bony canal through which they pass allow it. How far such an experiment may interrupt the Human Brain is not certain; from the difference in the size of the Arteries mentioned in our last Lecture.

The Circulation through the Brain is retarded by the right angles at which the Carotids are given off at the curvature of the Aorta, by the blood having to amount in opposition to its gravity, by the angles made by the Arteries when they enter the Cranium, by the convolutions of the Vessels and lastly and chiefly by the difference in the structure of the Arteries themselves, they being in this respect more like Veins. Notwithstanding the number and size of these Arteries, the Brain is not very vascular, for many of these terminate in red Veins, and others only carry serous blood, hence little blood enters the Brain although much passes into the Cranium. The pia Mater dips in forming fissures

and convolutions in the substance of the Brain, and Vessels accompany these. Hence the Brain is perforated by the Vessels of the Pia Mater in an infinite number of places, like the bones by the vessels of the Periosteum. The convolutions enlarge the surface for perforations. The vessels carrying the blood arise from the Aorta at its curvature forming numerous convolutions and ramifying on the Pia Mater previous to their entering the substance of the Brain.

But when we examine the interior substance of the Brain we do not find that red appearance that we do in other parts, and hence it seems that the minute branches only enter the Brain, while the large ones terminate in Veins upon the Dura Mater, so that only a small portion of the red part of the blood enters the Brain itself. The Blood after circulating through the Brain and Pia Mater is returned into sinuses which take the same convoluted course as the Arteries. Thus it descends agreeable to its own gravity, and prevents the Brain from being incommoded by any accumulation as it would otherwise be. The internal Jugular Veins form a very important part in the return of the blood, but there are also external Jugulars which with the Vertebral return some part. It may be asked how the blood is returned by the Veins when they ramify principally on the outside of the Cranium, but it is found that

the branches of the external have free communication with those of the internal Jugular through the different foramina, and therefore if the Brain be oppressed with blood an opening into the external Jugular would be of infinite service. The Vessels communicating with the external Jugular and facial Veins are called the Vasa emissaria.

They carry blood out of the Cranium and convey it into these Veins, and hence the relief afforded by opening them in certain cases. Many of the Veins of the Pia Mater terminate in the Longitudinal Sinus, in an opposite direction to that in which the blood is passing, which is from before backwards and thus a kind of clashing of Streams is produced. When we remove a small portion of Cranium we perceive a pulsatory motion of the Brain which has given rise to various conjectures.

If we examine closely we shall find the pulsation Synchronising with that of the wrist, and hence it has with reason been said that it arises from the pulsation of the Arteries within the Pia Mater. But independent of this there seems to be another kind of motion which exactly corresponds with the act of Respiration, for as Air is taken in or expelled, the Brain becomes flattened or elevated. During Inspiration the Cells being filled the circulation through the Lungs is free, but when Expiration is performed the Lungs is collapsed and the circulation through them is then impeded. This gives a temporary check to the

admission of Blood, in consequence of which it is delayed in the Jugular Veins and in those of the head, till an inspiration is again made and this explains the motion alluded to. (Thus then the Pulsation of the Brain may be said to depend on two causes, one corresponding with the motion of the Arteries, and the other with the action of Respiration.) The Brain it seems is the source and origin of Nerves, and these are to be considered as a continuation of the Brain, by which a communication is kept up between it and every part of the body. The Nerves arise either from the substance of the Brain or the Spinal marrow. Of these ten pair arise from the former, and thirty from the latter. But besides these there is another nerve, the Grand sympathetic or Intercostal, which does appear to arise from either, but from the numerous branches of others, and seems to be a nerve of general communication and sensation rather than of a particular origin: communicating with the Vertebral Nerves, the Par Vagus & the fifth & sixth pairs. It is useful in Pathology to know the distribution of Nerves, as they lead to a knowledge of many symptoms which otherwise are misunderstood or unknown. Nerves are dense and compact bodies, while inelastic, of a fibrous texture, and connected together by cellular substances. They are vascular & vary in structure, in some parts being soft and pulpy, in others more compact, and from this arises the difference in the various degrees of Sensation. The pulpy nerves as the Optic, olfactory, & auditory being

more easily acted upon by impressing causes. The fingers are considered as the instruments of feeling, and this is acquired in a great measure from habit. The bodies applied to these are matter in a gross tangible form, and therefore the nerves are strong and compact, and produce the sense of feeling in a great degree. The same holds with regard to matter applied to the Papilla of the Tongue, which are the organs of taste. The third branch of the fifth pair is going to the tongue, and is fibrous like those applied to the fingers and Muscles. When we come to consider the other sensations, as for instance, what makes impression on the organs of Sense, we do not find it to be matter in a tangible form.

The same with respect to the organ of vision, of Hearing and of Smelling. With respect to Vision it is caused by the subtle matter of light, acting upon the Retina, which is joined by the expansion of the optic nerve, and impressing on the Mind the Idea of the object seen. Hearing is not impressed on the mind by the body itself giving sound, and the nerves of these parts being of a soft delicate nature readily convey the Sensation. The sense of smelling may be explained in a similar manner. A grain of Musk for instance, will scent a whole Room, and yet it will not appear to be diminished in bulk, although it must have sent off something to act powerfully on the organs of Smelling. Hence it seems a law of the Animal Economy that the nerves should be of such structure

as adapted them to receive the different degrees of impression made on them by a variety of matter. Nerves are not possessed of irritability, that is, they have no power of contraction inherent in themselves, though by being stimulated a contraction will be excited in the muscles to which they are sent. This power is not generated by nerves, but is proceeding from the Brain.

I opened the Chest of a Dog and divided the Phrenic nerve on one side, I then irritated it below the division, and found that the diaphragm contracted, though for a short time only.

But upon irritating the Phrenic nerve which was not divided, I found the contraction of the diaphragm to continue the source of sensation not being cut off. It may be asked why the nerve did not cease its action entirely & immediately on the division, because it possessed some nervous energy previously sent from the Brain. The nerves like the Arteries have free communication with each other, but the branches of communication are much larger and are called Plexuses. There is another substance peculiar to nerves, which is that in some parts they have a knotted appearance, called Ganglion. The largest Plexus is the Axillary.

Various opinions have been formed respecting the use of these, some have supposed they possessed a muscular power of propelling the nervous influence further. Another idea was that they answered the purpose of appendages to the Brain

and had a power inherent in them of generating nervous influence. But a similar objection may be made to these conjectures, viz, that if there was any foundation for such ideas that Ganglion and Plexuses would be found in those parts which are at the greatest distance from the Brain, which is not the case.

Mr. Cline is of opinion, that they serve only to enlarge the surface for the origin of other nerves, and this opinion I think is most reasonable. It is observed in proof of this, that many filaments of nerves are going off at every Ganglion.

Lecture 26th

On the Economy of the Nerves.

The nerves may be considered in four points of view.

First, as the organs of sensation; Secondly, as giving mobility to Muscles; Thirdly, as having influence over the Glands with respect to their Secretions; Fourthly, as being organs of Sympathy.

In considering the Nerves as the organs of sensation, we must first make some observations on sensation itself.

Sensation is the application of matter to a part, which by means of the nerves refers or conveys an impression to the mind, and referred back by it to the part, and the sensation is thus produced. The mind sometimes errs, for sensation may

be conveyed to a part which does not exist. Thus after Amputation of a limb, the Patient will sometimes complain of a pain in the toe, the existence of this is impossible, but probably some of the filaments which went down to the toes, being in an irritable state and the mind being long habituated to convey the impressions made on these filaments to the toes, is sometime in correcting the error; but at last its judgement corrects its sensation. Sometimes the mind refers the impression it receives to a wrong place.

In the Nose the pain is felt in the orifice of the Nostril. Again with regard to internal parts, we are not able at all to judge of the seat of pain; and the reference made by the mind to these is often wrong, because they are not so much under its influence as the external parts of the body are.

Of Sensation there is great variety, but they may be all referred to two kinds; the Agreeable and Disagreeable. To the former we refer all pleasurable sensations and to the latter all those of a painful kind. Besides there is another kind of sensation which conveys the idea of soreness, this however is nothing more than an inordinate quantity of sensation. Before any sensation can be produced there must be a communication of Nervous substance between the part impressed and the mind; but this alone is not sufficient. It is necessary also that the impressing cause should act with some degree of force, thus if you draw a pin through the hand, though an impression be made no sensation is produced, but if

you use a knife the impression being made with some degree of force the pain is immediate. Another requisite to produce sensation is the impressing cause, which must be conveyed with a proper degree of velocity, or no effect will take place.

Thus in a dropsy though the Abdomen be much swelled, no painful sensation is produced, because the accumulation has been slow and gradual. Again impressions may be made too quick to convey any impression to the mind, & to produce the sensation of pain as is the case in Gun-shot wounds.

Besides force and velocity a certain condition of parts is likewise necessary, which shews that various parts differ in degrees of sensation, but if applied to the Eye the effect will be very painful. Some parts while in a healthy state appear to possess no sensation, but under a morbid state are susceptible of great pain and sensibility. This particularly applies to the Tendons. Sensation of parts vary with the periods of life.

In youth it is very acute, in old age it becomes dull and languid. Sensation depends also on the number and proportion of nerves going to a part. Thus the Nose Eye and Ear are very susceptible of sensation from the most subtle causes of impression, whereas the organs of taste and feeling require a greater force of this. To again when an Animal has any sense very acute such a part or organ has a larger proportion of nerves, than the same organ has in other Animals. Thus the Dog has large allfactory

Nerves than Man, and his sense of smelling is consequently more acute. The finer senses also as observed before are supplied with nerves of a Pulpy texture. The nerves seem to have something in their Oeconomy similar to muscles, that is from motion they are capable of enlarging, and if deprived of it they diminish. This I proved by dissection in two instances.

In a Boy that was deaf I found the Auditory Nerves only half its natural size, and the same in respect to the Optic nerve of a Man who was blind. These causes seem clearly to prove the fact.

The different nerves of the body, seem to possess different degrees of sensation. To prove this I divided the Par Vagum & Sciatic Nerves in Dogs, and I universally found that the Animals possessed the greatest degree of pain in the division of the latter, and the reason of it may be thus explained. The Par Vagum is distributed to the involuntary Muscles, and therefore not under the influence of the will, but the contrary is the case with regard to the Sciatic Nerve. If a drop of Tincture of Opium be poured on the Brain of a Frog, the Voluntary Muscles do not seem to act, while the Heart &c continue in action; and on the contrary, if Opium be dropped on the Heart the involuntary muscles loose their action, and those of the legs &c continue. From this fact observed by Mr Ashley Cooper it would seem that the Nervous influence supplying these kind of Muscles is somewhat of a different Nature. We are now

to observe the nerves giving mobility to the Muscles.

The muscle cannot act if the communication of the nervous influence be cut off. But what is the first Phenomenon now produced? Sensation first ceases from the communication with the Mind being destroyed. Nevertheless a Muscle does not immediately cease to act, which proves that the Brain has sent a sufficient quantity of nervous influence, adequate to its action for a certain time. The Heart being an involuntary Muscle, is not under the influence of the Mind, and therefore its action cannot be quickened, but passions will affect the Heart more or less according to its violence.

For instance palpitacion is often produced in this way, & yet the Will can have no influence over the Heart.

If the nerve going to the Heart be stimulated its action will not be increased, and hence the Abbe Fontana, and others have been led to consider the action of the Heart performed independent of nerves. But this does not appear to be the fact, for the sensation of palpitacion must be conveyed by the medium of the nerves. It may be farther asked why nerves are sent to these parts if they have no office to perform?

I do not therefore think that the Abbe is at all warranted in the conclusion he has drawn. There is something peculiar in Nerves which cannot be explained but by admitting of their decussating each other, that is, the nerves arising from one side of the head being distributed

to the other side of the head. It is on this principle only that we can account for Paralysis on one side being produced by an injury received on the opposite side of the head. Anatomists have not been able to ascertain this point. The influence of Nerves over the Secretions is very great. All the secretions are performed by the Arteries, but they are not capable of performing this office without the assistance of Nerves. But in what way do the Nerves act.

It is not by accelerating motion but by imparting a kind of vital energy. This appears evident in many instances where we can accelerate the secretions by the passions of the Mind.

The Secretion of Tears and Semen may be increased in this way, and without the aid of the Nerves the Gastric Juice may be diminished in quantity and vitiated in quality.

Dr. Cullen was of opinion that the Nerves prepared something from the blood necessary to Nutrition, but this certainly is not the case, for if a nerve going to a limb be divided, that limb still continues to grow, which incontestably proves that the Arteries and not the Nerves perform this office. Others again say that they have an influence over the Arteries and in that way are concerned, but an experiment I made will prove the contrary.

I divided the Sciatic, Obturator, and Crural Nerves of a Dog, on one side, and then also divided the Tendo Achillis on both sides. The Paralytic side struck against the ground and part of the os Calcis ulcerated and sloughed off, where the

Tendon ought to have been inserted, but the Tendon not being able to unite or increase in length, increased very much in bulk, & proves that parts are not only nourished, but even grow without nervous influence. Lastly, we are to consider the nerves as organs of Sympathy.

By Sympathy we mean an action set up in one part of the body, by an impression made on a distant part, thus irritation of the Tunica conjunctiva promotes a flood of Tears from the Lacrymal Gland. This arises from the communication of nerves, the fifth pair supplying filaments to both these parts, the branch of this pair being sent to the Lacrymal Gland. Again irritating this Membrane excites the Pupil to contract; this also is produced by means of the nervous influence. It is necessary this should be attended to in the disease called Amaurosis or Gutta Serena, for in this the Pupil is always dilated, but by irritating the Tunica conjunctiva it contracts. Another kind of Sympathy is what we call setting the Teeth on edge; but this sensation must be produced by different sounds first acting on the organs of Hearing, and by means of nervous connection be sent to the Teeth. It may still however be asked how this is produced, for the Portio Mollis which is the immediate organ of Hearing has no communication with the Nerve going to the Teeth. But though this is not the case, the Portio Dura sends off branches which communicate with the Portio Mollis, and others also with the nerves of the Teeth, & thus the sensation is accounted for. Another instance of Sympathy

is that inflammation in one Eye, irritates and inflames the other, which on a similar principle with the other instances arise from a communication with the optic nerves. Sympathy is sometimes conveyed to the origin of a nerve, by impressions being made on its extremity, and hence it is we account for that pain in the loins arising from *Aernia Humoralis*. The same also with respect to the Liver when diseased, giving rise to a pain on the shoulder. This has been ascertained by some to be the weight of the Liver drawing down the Diaphragm, and thereby stretching the Phrenic nerve, but this is not the fact, for the Liver when diseased is often diminished both in its bulk and weight. My opinion is that it arises from some other cause, which admits of a more satisfactory explanation.

When inflammation is situated on the upper part of the Liver, the Phrenic nerve which terminates in branches at that part is irritated by the exciting inflammation and thus the pain is produced. There are some circumstances of Sympathy however which cannot be explained on the principle of nervous communication. I knew an instance where the Tooth Ach always succeeded indigestion. We know also that light will affect the Iris exciting it to contract by acting on the Retina, which is the expansion of the optic nerve, but there is a communication between this and the Ciliary Plexus of nerves which supply the Iris, and therefore the light must fall on the Retina, and then on the Iris by consent of parts, for we do not know that

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the Iris is sensible of the impression of light. on this principle also we must account for sneezing being produced by irritation on the nose. The economy of the nerves is very complicate and some parts not at all understood. They are organized bodies having Arteries and Veins entering their substance, and consequently are capable of uniting when divided. The Abbe Fontana asserted that some Nerves, particularly the Sciatic were incapable of doing this. But experiments I made contradict this opinion of the Abbe's, and I found that a longer time was required for the union to be effected, which the Abbe did not allow. Nay they will even fill up if a considerable portion be removed. The union of a nerve in the first instance forms a kind of Knot by an effusion of blood from the extremities of the divided Vessels, and this gradually becomes of a nervous structure. Sometimes there is a Knot or enlargement, but merely a continuation of nervous substance.

Various opinions have been held respecting the union of Nerves. Whether the new formed substance possessed the same properties as the nerve in its primitive state or not. The Abbe Fontana made some experiments to prove this.

He first examined a Nerve in its primitive state with great accuracy; he afterwards divided the eighth pair in a Rabbit, and upon examining the reproduced part with a Microscope he asserts that it is the same with the nerve itself;

That he saw the nervous fibre entering its substance.

Dr. Hamhill who has written on this subject expressly denies this. But as Anatomical observation seems insufficient to prove this point, we must have recourse to some other test.

To that of Physiology, it must however first be granted me, that nothing but what is strictly nervous can do the office of nerves. It must also be acknowledged that if in consequence of a division of a nerve sensation be lost and again be recovered when that nerve is united, that it is brought about by this union. These two points I have clearly proved by experiments made on the eighth pair of nerves. If both these be divided at once, the Animal almost instantly dies, but if the division be made at the distance of nine days it has a great chance of recovery; this I have found in three successive instances. I divided one of these in a dog at the end of six weeks the other. He seemed much affected, lost his voice, and symptoms of dyspepsia supervened, but with great care he gradually recovered, though his voice ever remained altered. Some probably may object to this experiment by saying that as nerves communicate as well as act, the nervous energy may be carried on by Anastomosing branches, and therefore when the *Par Vagus* is divided, the function of the intercostal is increased to supply the deficiency of the former. If this be granted it may be said that the *Par Vagus* after

having been divided must become a useless Chord in the machine & that it may be divided a second time with impunity. The dog on whom the former experiment had been made was exactly in the situation to answer this objection. I had kept him nineteen months and he was quite hearty, but a second time I divided the nerve & he lived only two days after. I am therefore clear of opinion that the reproduced substance of a divided nerve is of the structure and importance as the original nerve itself and though Anatomy will not prove this clearly, Physiology certainly does.

Different Theories have been given respecting the mode in which the nerves perform their functions, some have said it was by a vibrating motion, others that they were tubes conveying a subtle fluid from the Brain. If the latter opinion was true, it must necessarily follow, that they must swell like an Artery on the application of a ligature, but this is not found to be the case. A more general opinion now is that they have the power of generating an elastic fluid & acting on Electric principles. Experiments which have been made by Mr. Walsh and Mr. Hunter seem to determine this point.

In the *Gymnotus Electricus* there is a particular part which on being touched gives to the person a considerable shock. Many experiments have since been made here and in Italy which seems further to prove this principle of the Nerves. If the lower extremities of a Frog be stripped

of their skin, and the laying bare of the nerve be performed and it be coated with a bit of tinfoil, and the nerve of the back be covered also with some other metal on the application of some metallic substance to both at the same time as a conductor; whether it be gold or silver as a discharger, the Muscles of the thigh will be excited very powerfully to contract.

Many experiments of this kind have been made, and have since been published to the world.

Lecture 27th Of Muscular Motion.

This is inherent in most Animals, a power by which they can move a part or the whole of the body, and this is called Low motion. It is performed by Muscles. In speaking of Muscles we are not to confine our ideas of them to particular appearances, for the Intestinal canal and Arteries though they have not the appearance of Muscles in general have nevertheless Muscular fibres. We judge of Muscularity in two ways; first by comparison. This is however rather uncertain, from people differing about what is and what is not a muscle. Thus some say that the Uterus is not Muscular, nor Flies which we know have motion. Hence

we must have recourse to some other test. Colour is a very doubtful one, for the redness of a muscle is depending on the blood. Some muscles are white as those of the Lobster, and many insects; and you may macerate a red muscle in water till it becomes white. Colour therefore we see is by no means necessary but quite accidental. I believe the most certain test will be found to be action, or such a state of parts as will give contraction under the application of Stimuli.

Besides that particular assemblage of fibres we call muscular, they are organized having blood vessels, nerves, and Absorbents. The Arteries may be injected, and from the appearance they give, one might suppose a muscle was composed of one entire mass of blood vessels.

The nature and mode of communication between the ramification of Arteries, and the Muscular fibres admits of much speculation and conjecture. That Muscles have Absorbents is evident from poisons being taken into the constitution if applied to them, and the pain caused by puncturing muscles, is decisive of their possessing nerves. Dr. Cullen thought that muscles were made up completely of nerves, some sentient, others not, but this opinion does not appear to be well founded, for some parts which have great Muscularity have but few nerves, as the Heart. An ingenious Physiologist mentioned some years ago, that muscles were

nothing more than blood vessels, but without any foundation or truth. Some have said that muscles were elastic because they have a power of elongation, but this power arises from their living principle and their possessing irritability.

If a muscle be stretched out it will not return to its former place if deprived of life, and therefore we may say they are ductile and not elastic. In the living body muscles are in a state either of elongation or contraction; neither of these states are natural, but a medium between them. Before a muscle is capable of action it must possess certain properties, as life, tone, irritability, and connection with the mind by means of nerves. With respect to life it is universally acknowledged and therefore needs no argument. But it is necessary to understand what is meant by tone. I consider the term owes its origin to music, as when an instrument is in its proper state we may say it has tone.

A muscle in health is firm, plump and hard, and then tonic; and in a state contrary to this, atonic.

These properties certainly depend on a due supply of blood. There is connection between the tone and action of muscles.

A muscle cannot act with force unless it possesses tone, nor can it possess tone without a constant regular action.

If I tie up an arm which is in a tonic state, in six weeks the motion would be lost from the impeded slow

and the latter to those made up of a number of small ones connected together. This does not respect their functions nor is it consistent with nature. For instance, the Kidney in some Animals is of one class and in others of another; even in the same Animal there is a difference at different times of life.

Thus the Kidneys of a Lotus is conglomerate, but that of an Adult conglobate. Glands have many things in common as Arteries, Veins, and Absorbents, but there is something peculiar to each. The Vessels of the Kidney have one centre of communication, those of the Liver have two. Some Glands again have only one excretory duct as the Liver and Testis, others as the Lacrymal Gland many; These Lacrymal ducts are five or six in number though very small, and an advantage arising from this number is that the tears which lubricate the Eye are in consequence more easily diffused. The lids might in a great measure serve to equalize the distribution, but the number of ducts certainly assists to this purpose. Where there are a number of ducts, some glands have receptacles for their secretion, as the Female breasts. Here the ducts themselves are very much enlarged, and become the receptacles. In some instances there are bladders which serve as receptacles to glands as in the cases of the Liver and Kidney. Much has been said about the internal structure of Glands, and great pains has been taken to determine this from a supposition that it would explain their functions.

Sphincters act by possessing tone. They do not always act but their tone gives them that disposition to attain a contracted state on ordinary occasions. No muscle is capable of constant action and the Heart is no exception to this, its systole being only its state of action, while its diastole is its state of relax.

A muscle cannot act without irritability. By this we mean a disposition to act on the application of Stimulus, and the action of a muscle being its contraction, we call that disposition its state of irritability. Baron Haller supposed this power to be inherent in muscles, independent of nerves, and therefore called it *vis insita*; he reasons both from analogy and experiment.

To prove this Vegetables he says will contract without nerves particularly the sensitive plant, and also will muscles deprived of nerves, and all communication with the Brain.

He divided the nerves going to the lower extremities of a dog, and stimulated the Gastrocnemii muscle and found it contract, which he considered as a proof of the *vis insita*.

But I consider the muscle continuing to contract after the division of the nerves proceeded from the nervous energy of the part not being entirely exhausted. I repeated this experiment by dividing the Sciatic, Obturator and Crural nerves of a dog, at their first appearance up the thigh.

I then punctured the Gastrocnemius and it contracted, not from the *vis insita*, but from the presence of nervous energy

for it would not do so in forty eight hours though it possessed Life. I passed slight Electric shocks through it without producing contraction. Also an experiment before mentioned may be brought here in proof of this opinion! It is when the Phrenic Nerve is divided going to the Diaphragm on one side, after some time on stimulating the Muscle on that side, that it would not act, but on the other side where the nerve was divided and consequently the communication with the Mind kept up, it acted very powerfully. Hence I consider the irritability of a Muscle to depend on the *Vis Nervosa* and not on the *Vis insita*. A Muscle when in action is shorter than before.

But this shortening is not essential to action. It only shews strength enough to overcome the resistance made.

Thus I attempt to heave a great weight, and find that I cannot, the Muscles are evidently in action though they are not shortened. It will therefore be better to say, that action consists in an endeavour to shorten, rather than in an absolute shortening. It has been a question much disputed to what degree a Muscle could shorten itself. Some say to one third, others say to one half its length, but this is not very easy to prove. That they will shorten to a great degree is evident, in many instances, as in those of the *Distinctus An. Sc.*

Those Muscles also which move the bladder will allow it to be expanded, untill it contains a gallon, and reduce it

till it can contain nothing. If we compute from the distention and contraction we might say, that Muscles might contract themselves from five to six times their greatest length.

Some who have attended to the Phenomenon of Muscular action have said that they varied in colour and size while in the contracted state. This they thought from observing the Heart of a Frog, which during the systole, while its cavities are empty, became pale. But this variety is only observable in the Frog, for in that Animal the Heart is transparent and the blood may be seen in its cavities, and hence the paleness or redness depends on the presence or the absence of the blood circulating through it, and this paleness does not exist in other Animals.

If also you put the Arm into water, and then put the Muscles into action, the water will be found neither to rise or sink.

An experiment of Dr. Blands is much to this point, he procured an oil flask, in which he put part of an Eel; he then stimulated the rest to action by passing down a small horn tube in the neck of the flask and pricking it, but though moving a great deal it did not in the least raise the water in the neck of the flask. (Indeed it is difficult to conceive how it should, for the circulation being cut off all possibility of increase in bulk was entirely cut off.) Hence it is evident that there is neither an increase or diminution of bulk. If it becomes swelled it loses in length what it gained in thickness. — — —

The mind in general directs the action of the Muscles, and this is done from experience. It prescribes the degree of force necessary to overcome the resistance, but the mind is sometimes deceived in this respect, and mistaking a light for a heavy body; the body is moved with a jerk.

Some have attempted to ascertain the degree of force with which Muscles can act; and have said that this would be determined by the extent of power that they would command. Thus if the Biceps, Brachialis internus &c. could just raise the weight of Fifty pounds, they said that, that was the extent of force which the Muscles were capable of exerting. But this is a wrong mode of reasoning, for Muscles act on the principle of a Lever reversed.

With respect to Muscles nature seems more to have considered quick than strong action. And though by a variation in the centre of action a greater force might be obtained, yet the loss of that is compensated for by the greater quickness that is acquired. Muscles are of three Kinds, Voluntary, involuntary, and mixed. Of the first are those of the extremities; of the second, those that begin their action with life, and cease it with death; and of the third Kind are those of Respiration, whose action can be suspended for a short time only. We find that the Voluntary Muscles soon become fatigued, but the involuntary do not. If we breathe

by the Will, the Muscles of Respiration soon become fatigued while in ordinary breathing this does not take place.

We know no difference in the structure of fibres which compose the Heart and other Muscles. From this it would seem that the fatigued depended more on the Mind than the Muscle, and I believe this to be the case. A person after using great exercise finds his mind unfit for intellectual pursuits till after rest or sleep. The fatigue seems partly to depend on the mind and on the nerve supplying the Muscle. If it resided in the mind only one Arm being fatigued by exercise, the other would be also.

The Will is a considerable time before it directs the Muscular action properly. This we can see in Children learning to walk, in whom the motion is not progressive, but the limbs are thrown about at random.

Muscles are capable of acquiring extraordinary quick action. Of this we see instances in professors of music, the motion of whose fingers are remarkably quick. — — —

Lecture 28th Of the Secretions.

When considering the properties of the blood we

confined our observations to its important purposes of supporting the body. We are now to consider it in another point of view, as forming the secretions. Of these there is a great variety, some answering one purpose and some another.

Some are necessary to the health and support of life, as the Saliva, Gastric and Pancreatic juice &c. Others as the Fat seem to answer a more distant exigency, by supporting as well the body under distress as contributing to its beauty and form.

Bile is answering a very important purpose, being to act on the Intestinal canal as their natural cathartic.

Several others are of great use to facilitate motion as the Liquor Pericardii, Synovia, Intestinal fluid &c. There are others again which do not seem to answer purposes so well marked, as for instance, the perspirable matter, Urine, Exhalation from the Lungs, and excrementitious matter. They seem to benefit the machine only by being thrown off from it.

Some others appear destined to particular purposes in perpetuating the species, as the Semen, the fluid of the Vesiculae Seminales and Prostate. Females have also secretions of the Ovaria and other parts, and likewise a peculiar secretion as the Milk for nourishing the young after birth. Particular Animals are found to have particular secretions. Ants secrete an acid fluid. The white of an Egg seems to be a secreted fluid from the vascular membrane which encloses it. This membrane is too

vascular for the more purpose of its being nourished, & a large quantity of blood seems sent to it to furnish this secretion.

Fish have a small bladder containing Air, and strange as this may seem it appears from an examination of the structure of the bladder to be secreted by it. There are other secretions belonging to particular Animals which are poisonous, as that of the Wasp, Bug, Bee, Rattle Snake &c. A natural secretion may become poisonous: this is remarkable in the Mad Dog when the Saliva is poisonously impregnated. We must distinguish natural and artificial secretions, the first are regular and constant, the latter arising from accident, as in the case of Pus. This is a bland mild fluid, but it is often poisonous from being impregnated with Venereal and Variolous matter.

Some secretions resemble the elementary part of the blood as the Urine, Tears, &c, not that they are exactly the same but differ only a little from them. Others again are totally different, that they would appear to be created not separated from the blood, as the Bile, Milk, Ear-wax &c. The properties of these different fluids are various and diversified as the Glands which secrete them. Secretions which at first appear Homogeneous will by spontaneous separation become Heterogeneous.

Thus Milk separated into Cream, and what we call skim Milk under heat, Cream again separated into Butter and another kind, called butter-milk. These again may be separated

by a Chemist. Skim milk separates into water, Sugar & Whey and by the addition of Rennet a solid chord is produced from it.

Of the manner in which these fluids exist in the blood we are quite ignorant, that they did exist we cannot doubt, as every thing is separated from the blood, by the various offices of different glands. Every secretion has its peculiar organ or gland; these organs have different forms and hence a division of them into simple and compound.

Of the first kind are the mucous secretions, & the compound are those which have Arteries, Veins, nerves, Absorbents and excretory duct. Of glands there are great variety.

The term refers only to the figure, but we ought to refer to the function of a part. Secreting organs are sometimes membranous as the Stomach. This has no particular organ secreting the Gastric Juice, but the whole internal Membrane is performing that office, and therefore we cannot properly ~~the~~ refer the idea of gland to a figure.

We know that the business of the secretion is to dissolve and this it will do more readily in proportion of surface for its action. Hence solution is more readily performed in the Stomach by this fluid than if it was poured out by a few excretory ducts. And hence the Arteries have these two offices that of supplying blood, & answering as excretory ducts. Another simple class of glands is that

which has follicles or crypts. The Follicles do not secrete but are receptacles only, the secretions being performed by Vessels. The Tongue is a Gland of this class.

In the Face about the Nose, Lips, and also the Ears, are a number of these follicles, which contain a sebaceous fluid. These have an outlet, but in other instances, as those of Cells, there is none. The membrane forming these cells secrete fat, and the Absorbents take it up, and perform the office of Excretories.

The Synovia is also taken up by the Absorbents. What we have already said principally respect simple Glands, but others are more compound.

They have an Artery, Veins Nerves Absorbents and excretory duct, all connected together, and enclosed in one common Membrane. Of this kind is the Kidney, which has an Artery to carry blood, and Veins to return the superfluity; and after the Urine is formed, an excretory duct conveys it into the bladder.

The Absorbents here are few in comparison with other parts. This division of Glands into simple and compound arises more from their use than their figure, and is certainly the most Physiological. Sylvius made a division of Glands into Conglobate and Conglomerate, the former applying to those which form one regular uniform mass,

circulation produced by the bandage. Some particular Muscles from being in constant action will greatly increase in size, while other Muscles in the same body will not be at all changed.

Thus a Pugilist has great muscularity about the breast; the famous Mendoza though otherwise not very lusty is very strong about this part, and I am informed he acquired this increased bulk in the space of about two or three years, from the constant exercise he made use of. In the same manner a Fencer has great power in the Muscle of his Thumb and Wrist.

Dancers, of the Legs &c. I could distinguish Watermen from any other people, by the Muscles of their shoulder.

In them the *Latissimus dorsi* which moves the shoulder is plumper than in any others, and this proceeds from the constant action of rowing. As Tone is preserved by action, so it is lost for want of it, but it may be restored to Muscles by the Mind directing them to act. We are to distinguish between the Tone and action of the Muscle. We call it Tonic when it is capable of acting powerfully, but we do not mean to say that the tone of Muscles is the cause of its contraction but that in this state there is a very ready disposition to action. Thus were Muscles antagonizing, if one set be divided, the other will draw them involuntarily as in the instance of the Arm. Suppose the extensors of the hand, were cut through, the flexors would draw them involuntarily.

There are two opinions which prevail on this subject. Malpighi states that between the extremities of the Artery & the excretory duct there is a follicle or cell interposed.

But Reysach from injecting a Kidney denies this, and said it was nothing more than extravasation. From very minute injection however I am convinced that Malpighi is right. The Veno Portum has its ramification terminating in two ways, one in cells which have sides and angles, and the other in the beginning of the Hepatic Veins. The Cysto or Corpora Globosa in the Kidney was very visible, from which other small vessels are seen to arise. Mr. Hewson thought they were convolutions of Vessels only, but in this he was mistaken. Though in the Testis this convolution of Vessels is very evident. But could we discover the exact structure of Glands, it would help us very little in ascertaining the mode in which they perform this office. Fashion in a great measure has governed the opinions with regard to the manner in which secretion was performed. At one time it was thought that Vessels had particular figures according to the form of the particles of fluids they were to convey, and secretion was thus accounted for on Mechanical principles. At another time all secretions were said to be carried on by fermentation. But as some glands do not always secrete, where does this fermenting principle exist before the age of puberty? It has been said to be a fermentation

of a peculiar kind which leads us to enquire what fermentation is.

It is a change which certain moist substances or fluids undergo, during which time an Intestine commotion takes place, from the extractions of Elastic Matter, and opacity is produced.

Secretion cannot be performed without life, and fermentation can, for it requires only fluidity, warmth, and air.

Secretion is a forced change on the blood, but fermentation is a spontaneous one on the substance concerned.

The secretions are various though the blood from which they are formed, is always the same, but place out of the body the same materials and they will always give you the same substance. Secretion often takes place very quickly, fermentation is slow and progressive. Secretion as those of the Tears & Semen, are increased by the passions of the mind, causes which cannot influence the principle of fermentation.

The Urine also may become thin, or the Gastric juice, sour under particular states of the mind. Now the Phenomena differ so much from those of fermentation, that we cannot allow it to be at all concerned in the business of secretion. Therefore we must say that life and nervous energy are essential, but how they act perhaps we shall never be able to explain.

The Stomach does not secrete if the Nerves going to it be effectually divided. Secretions at first are not perfect, water seems to enter into their composition, but the Absorbents take care

to remove this and thereby render the secretion more concentrated and active. The Liver has numerous Absorbents.

In the Hepatic ducts the Bile is much diluted, but in the Gall bladder it is much purer. Stimuli increase the secretions and sometimes particularly so. Thus Mercury increases the Salivary Secretion, the Pancreatic, the Urinary, and Perspiratory. It is not always necessary that Stimuli should come into contact with the secreting organ itself. For instance, if the Tunica Conjunctiva be Stimulated, the Lacrymal Gland will secrete abundantly. There is something of a balance between the secretions, Viz, when one is increased the other is diminished. This obtains chiefly in the more watery secretions, as those of the Perspirable Matter and Urine.

In winter the secretion of Urine is abundant, the perspirable matter being then but little, but in the summer the contrary takes place. A Person making water before he enters a warm room (as a play house) would not again want to void it during the time he remained there perspiring, or even if he had an impulse before, but neglected to obey it the inclination would soon go off in consequence of the quantity of matter passing off by Perspiration.

Lecture 29th

Of the Secretion of Urine

As we are at all times in the habit of taking into the body more fluids than is necessary for its support, the Vessels must always be over distended were there not outlets for carrying off the superfluous quantity. These emunctories are principally the exhalents of the Lungs carrying off the more watery parts of the blood; Secondly the discharge of Perspirable fluid explained by Sanctorius; and the other is the Kidney whose office we are now to consider. The Kidneys are two in number, situated in the Lumbar region, their figure is well known.

As they give rise to a copious secretion, they must necessarily be supplied with a large quantity of blood. The vessels carrying the blood, are the Emulgent Arteries, which pass off from the Aorta, the number of which are not always the same being sometimes two, three, four, or more. They enter at the part of the Kidney called its Sinus; but previous to their entrance they divide into several branches, and in the substance of the organ they subdivide into Capillary Vessels.

As the Arteries are large so there must be corresponding Veins to return the superfluous quantity of blood. There are

the Emulgent which sometimes like the Arteries vary in number.

The Kidneys are also furnished with Nerves and Absorbents but these latter are not so numerous as in the Liver. As that is an organ secreting a large quantity of fluid, it is necessary there should be a tube or canal to carry it off and this is done by the Ureter. If we examine the Kidney we find it of a very different structure in different parts, one part is called the tubular and is whitish and the other being most exterior takes the name of Cortical. But in the Human Kidney these parts intermix with each other, and therefore the distinction is not exact.

The cortical part is very vascular and is the only one which secretes. When the Emulgent Artery has ramified very minutely it terminates in small cells called *Corpora Lobosa* or *Crypto*. From minute injection and examination with a Microscope, I have no doubt of these cells in other Animals, & which tends to strengthen the opinion of Malpighi, that the Kidney is of a Follicular structure. As blood is deposited in those *Crypto* there must be Veins arising from them to carry off the superfluous quantity. Likewise another set of vessels communicating with the *Crypto* are small excretory ducts, *Tubuli Uriniferi*.

These originate in the *Crypto*, and terminate in certain processes called Mamillary from their resemblance to the Mamilla.

They are about twelve or fourteen in number containing a great many Uriniferous tubes, from which a fluid may be squeezed

and are mixed in some measure with the Cortical part of the Kidney.

From the Mamillary processes the Urine passes very slowly into the Infundibula, which are Membranous Cells, and the slowness of its motion allows time for Calculus Concretions to form in these parts.

After passing from the Infundibula the Urine gets into the pelvis of the Kidney and is from thence conveyed by the Ureters into the bladder. Some have considered the Ureters as possessing a Muscular power. Anatomically I have not been able to discover this, and hence other tests have been resorted to. Some have stimulated the Ureters with pointed instruments and therefore can deny it, however in subjects that have died and in whom Calculus excretions were lodged in the Ureters I have found these distended. Now we know that other Muscular parts will recover their dimensions as soon as the obstructing cause is removed, but this I did not find to take place with respect to the Ureters. From this and other reasons I am inclined to think, that if they contain any Muscularity it must be very inconsiderable. An eminent professor argues very strongly for their Muscular structure and from the circumstance of Opium diminishing pain of the moving fibres of the Ureter when administered in Calculus complaints and rendering them passive. We secrete a smaller quantity of Water at one time than another, in Summer less than Winter, and the reason is that it is thrown out by the Skin. Age has influence over the secretion, Old people secrete more than

Young for the reason above mentioned. The skin of old people is dry, that of young moist, and hence there is a greater secretion from the former. The quantity of fluid we take in & the nature of it may also influence the secretion. Another cause influencing the secretion of Urine is the action of the Diuretics. Some have thought there was a class of Medicines which determined to this organ, as well as to the Stomach, and have been in the habit of calling all Medicines Diuretics which increase the flow of Urine, but there is no Medicine which has a specific action on this organ, the Diuretic effect depending on many circumstances which are very uncertain. If you give a patient a Diuretic Medicine, and put him afterwards in a warm bed, he will secrete very little Urine, but a great deal of fluid will pass off by the skin. In Dropsy there is always an increased action of the exhalents. We give Medicines to produce Diuretic effects but we are disappointed.

Now why do not Medicines act upon the Kidney at this as well as at any other time? The reason is the exhalents throw out excessively, and the Medicine acts not on the Kidney in consequence, for so much passing off by one emunctory, of course less must pass off by the other.

But if the increased action of the exhalents be stopped, then the Kidney would secrete, nay, suspend the exhalent

action and the water which was previously poured out being absorbed would increase the Urinary secretion.

In the case of ovarian dropsy that bursted, the water was effused into the cavity of the Abdomen and the Absorbents of that part not being diseased took it up, and a great secretion of Urine followed. The Urinary secretion may be morbidly affected in different ways, one is from Diabetes, which consists in a copious secretion of Urine not natural, but pale and containing a large portion of Saccharine Matter. Experiments have been made to ascertain the quantity of this in twenty four hours, Quarts and even Gallons may be voided and may continue so for many days. There is a greater dryness about the skin and Fauces, and it is not to be wondered at that other emunctories want fluid, when this has such an excessive discharge. Now how is this fluid supplied.

For the quantity voided off, exceeds the quantity taken in. It has been said that the Absorbents took in moisture from the Air and hence it has been proposed to rub the body over with oil, this was tried at Edinburgh but did not succeed. The cause of this complaint is not clear, for medicines of very different actions have been found to cure, as Steel, Aloes, Bark &c. Dovers powders have also been successfully employed. Some have thought

That the *Primo Vio* has Absorbents communicating with the bladder. M^r. Sauvoin in a Thesis delivered at Edinburgh supported this opinion, and thought that the Vessels performed their action, by conveying the Chyle in part into the Urine, but this is not at all probable.

The mind has influence over the secretion. In Hypochondriacal people the Urine is crude, pale and thin, and so it is in the cold stage of fever, but when the contribution is taken off it deposits a Sediment. Substances taken into the System may in different ways affect the Urine, thus Rhubarb and Saffron will affect its colour, & Asparagus and Turpentine its smell. The Ureters are generally admitted to be those canals which convey the Urine from the Kidney into the bladder, but some have said they are not exclusively so. They have tied the Ureters, and said the Animal afterwards discharged Urine. But Urine might have been contained in the bladder before the Ureters were tied, and those who have taken the precaution to empty the bladder have found the experiment to fail. Some say that Urine being voided so soon after liquor is taken proves this. But is the same fluid voided that is drank? No.

Does the Stomach sympathize with the Kidney and thereby stimulate its secretion? It has been a question how this Saccharine has been produced in the Urine,

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whether it was a disease in the secreting power of the Kidney, or as some have thought in the assimilating organs.

If it was in the assimilating organs the serum of the blood should contain Sugar, but this has never been proved, hence it is probable some diseased action in the organ itself, but as yet we know only the disease by the Phenomena it exhibits and are ignorant of its nature.

Mr. Darwin wished to give an air of demonstration to his notion of Absorption in a retrograde manner by the following experiments. He drank punch until he was almost intoxicated, and then took a quantity of Asparagus and Nitre. He voided his Urine soon after and said he detected the smell of Asparagus in it, * and thus making touch paper; having done this he was immediately bled, but the serum of the blood contained neither of these substances, whence he inferred that they did not get into the bladder by the medium of the blood, but through the course of direct Absorption.

I have asked the question before, does the Stomach Sympathize with the Kidney and thereby stimulate its action? This is not improbable and the Sympathy of the bladder with the hand when put into cold water is well known. The Urine passes into the bladder in a

* and also the presence of nitre by dipping paper into it,

slow and gradual manner guttation, this we have had an opportunity in seeing in a Foreigner (Matt^o Nysum) whose bladder was deficient and the Uter terminated on the surface of the Abdomen. From him the Urine was constantly dribbling away. Such a person would be a favourable subjects for trying experiments on the action of Diuretics as we could easily determine their slow or speedy effects. In consequence of this gradual flow the bladder is able to contain more, than if the distention was more rapid. The Urine is contained sometime in the bladder before it is evacuated. on what does this depend?

There are surrounding the Membranous part of the Urethra Muscular fibres called sphincter which seem to act on two principles, first by their Tonic power they are capable of retaining the Urine, until the bladder is distended to a considerable degree.

After this power is overcome the Mind is called into aid and enables them more forcibly to retain it. But suppose there is a great distention, the Levator Ani in that case by drawing up the Membranous part of the Urethra against the Pubes will narrow the canal and in that way assist the power of retention. The power of opposing this sphincter are Muscular fibres in the bladder itself. There are two orders of these one passing into a Longitudinal, the other in a circular direction, the former called Detrusor Urinae act very forcibly. The fibres are capable of emptying

the bladder completely. An executed subject will void his Urine entirely, and his bladder be closed. After being long detained there is a difficulty in expelling the Urine from the fibres having been too much stretched but afterwards the power will again be recovered.

Sometimes the power to void Urine is quite lost & it becomes necessary to introduce a Catheter, and use other means. At first the Urine dribbles away slowly, and then more rapidly.

In those who have had frequent retentions of Urine the Muscularity of the bladder is much increased from the frequent stimulus acting upon the fibres. Sometimes a retention of Urine takes place from causes affecting the retaining powers, as spasm upon the sphincter which over balance the expelling powers. In this case Opium, the warm bath, Clysters &c may be used, and Mr. Cline found the Tinct. Ferri: Muriat. successful in the dose of ten drops every ten minutes until it produce Nausea. An inability to retain the Urine is produced by various causes, as Calculi irritating the bladder, and by degrees weakening the retaining powers.

Gonorrhoea has been known to produce this effect. In one case of this kind the bladder was so irritable that the Patient could not retain his Urine five minutes together. I made use of Lime water and Bark which in a few days relieved him.

Lecture 30th

On the Secretion of Bile.

We are now to consider the organ destined to the secretion of Bile, previous to which it may be proper to make some observations on the nature of the Bile itself. The Bile is a green fluid bitter and Pungent. In the Gall Bladder it is concentrated but when more diluted it is of a yellow colour, and hence the yellowness in the Jaundice. It has a certain degree of viscosity, lathers under agitation and possesses Saponaceous properties, which causes it to be employed by Scourers in cleaning of cloths.

There is a reason to believe from these appearances, that Bile possesses heterogeneous properties. It has often been the subject of Chemical examination, and it was usual in this process to sublime it, and examine the residuum, but the Analysis so performed was imperfect. The science of Chemistry having however become more extensive by a knowledge of tests having been substituted for the old mode by heat, Vapour arises from Bile under heat, impregnated with a degree of odour which is its watery part, and if we distil it there remains a thick inflammable resinous like substance. As Bile has considerable viscosity, I wished to

know whether it did not owe this property as in other instances to the presence of mucus. With the assistance of Dr. Babington I made the following experiments.

Where mucilage is combined with water, it will on the addition of spirits of wine be separated and the water will unite with the spirit. This principle we applied to the Bile, and in adding to it some spirit of wine a green watery fluid separated and left behind a mucus. Probably the mucilaginous principle is greater in Gall bladders rendering the Bile more viscid. The liquor thus obtained I evaporated by heat, the Alcohol was first evaporated and the residuum was resinous. It is this resin which imparts to the Bile its colour and taste, hence then Viscidity, odour, fluidity, taste and colour are accounted for. But we spoke of a Taponaceous principle which we suppose is the presence of an Alkali.

To ascertain which we made the following experiment. Having reserved some of the watery part of the Bile, we added to it the marine acid from which we obtained cubic crystals which deflagrated in the fire and were found to be common salt.

And again by addition of Vitriolic acid we obtained Glauber salt. From this it seems that the Alkaline principle is of the Mineral kind. But as we ordinarily take in so much common salt, it may perhaps be said this exists in the blood in its proper form. By adding however a solution of Silver in the Nitrous acid

to detect this it failed, whereas it ought to have given the substance we call *Luna cornea*. These then are the principles and the constituent properties of Bile. For the secretion of this fluid nature has destined a large organ the Liver, situated in the cavity of the Abdomen in the Epigastrie and right Hypochondriac regions. Its figure is not easily understood as it describes no mathematical figure with which we are acquainted. It is composed of three Lobes, the right of which is the largest, the left smaller, and the third, the *Lobulus Spiegelii* is smaller still. It is connected to the Diaphragm by the reflections of Peritoneum. As the Liver performs a secretory office, and all the secretions being derived from the blood, it must follow that this organ must be plentifully supplied with it. In all glands there are Arteries which carry blood as well for the nourishment of the organ as its secretions, & Veins to bring back the superabundant quantity, but in the Liver there is a peculiarity in this respect. The Artery enters the Liver at the Porta and ramifies through it, and the blood is returned by the Hepatic Veins into the Vena cava. This Artery sends also a branch to the Gall bladder as well as to the *Gastrica dextra* and *Pylorica* to the Stomach. But the Artery in this case not being the vessel supplying blood for the secretion, what one is it that answers the purpose? It is the *Vena portarum* which serves in some measure to perform the offices of an Artery & Vein. The Chyliferous Viscera are supplied with blood, by the *celiac*,

superior and inferior Mesenteric Arteries. These after ramifying terminate in Veins, and these Veins ultimately terminate in one trunk the Vena Portarum. The Vena Portarum observes equally the same laws in its ramifications as other Vessels, & the Hepatic Veins return the superabundant blood of the Vena Portarum as well as that of the Hepatic Artery. But what is the most minute termination of the ramifications of this Vessel, do they terminate in the duct itself or follicles? We shall not enter minutely into the opinions of Ruy-sch or Malpighi on this subject, but show some dots and appearances which favour the former opinion. From these it appears that there are Cells or follicles interposed between the extremities of the Vessels *Viri Biliarii*, and that these join and form the Hepatic duct by which the Bile is excreted from the Liver.

The Hepatic duct in its passage to the Duodenum receives another duct from the Gall-bladder called the Cystic, and these uniting form the *Ductus communis: Choledochus*. This duct enters the Duodenum very obliquely passing half an inch between its coats before it terminates in the Intestine, which it is supplying with Bile. The Duodenum has a longitudinal & circular order of Muscular fibres and the latter constrict the duct as it enters. The Liver is plentifully supplied with Absorbents. The Bile when first formed is very watery, and the Absorbents which arise from the Hepatic duct and other

parts, are evidently taking up the more watery parts of this fluid, and leave the remainder more concentrated than it was before. A vein being the vessel carrying on the process of secreting this fluid, and this being the only instance of the kind we meet with, it has been said that the Hepatic Artery assists in this purpose. One reason of this opinion is from analogy, the Artery being the source of secretion & nourishment in other glands. Another reason is that the Artery is large enough to answer both purposes, and too large merely for the purpose of supplying nourishment. It is said that the Bronchial Arteries nourish the Lungs, but it is highly probable that the pulmonary Artery fits the blood for nourishing them, as well as transmitting it through them; and adhesions being injected from the Pulmonary Artery which has taken place in the Lungs prove that the branches of it assist in nourishing them. Another reason assigned is, that if you inject the Hepatic Artery, you fill the *Pori Biliares* but this is fallacious. The injection here takes a very circuitous course. If you inject the Arteries it passes into the Veins; but first tying the Veins the injection remains in them.

Now these Veins as before observed communicate with the *Vena Portarum*, as well as the Hepatic Artery, and the injection in consequence regurgitates into the Veins, & from thence into the *Pori Biliares*. Some have said that the blood

was not entirely Venous, though returned from the different Viscera, but this is merely supposition.

Baron Adler thought that the Veins of the Omentum absorbed fat which was mixed with the blood, and which formed the Bile, but no test can discover any difference in this and other Venous Blood. We therefore reputed the Spleen at all assisting in preparing the blood for Secrecion. The Venous blood is slow in its circulation, in the Vena Porta it is the same, and in its branches may be particularly so, which very much favours the secretion of Bile. But though the secretion of Bile is formed from Venous blood yet it may in case of necessity be formed from the Arterial; and Mr. Abernethy met with a case where the Vena Portarum emptied itself into the Vena Cava, and the Hepatic Artery supplied the secretion, though the Bile was in this case imperfect. In what part of the Liver does the secretion take place? The branches of the Vena Portarum terminate in the Hepatic Veins, but these branches are extremely minute before they have this termination, as vessels always terminate in capillaries before they become returning veins.

The crypts, or follicles at the extremities of these vessels appear to be the place where the secretion is performed, though as we have before said the Bile is here imperfect from the quantity of water it contains, and which is afterwards taken up by the Absorbents. The change seems to be produced in the crypts, after the blood has passed

through the ramifications of the Vena Portarum; else the constitution would be exposed to continual Jaundice.

The ramifications of the Vena Portarum have two terminations one in a follicle, the other in an Hepatic Vein. The Bile passes sometimes more plentifully than others. It is generally thought that it is made to regurgitate into the Gall bladder by the contraction of the circular fibres of the Duodenum or through the Ductus communis Choledochus; the bladder in this case serving as a reservoir. But is this the only use of the Gall bladder.

If so, and the cause was always acting it would in time become so much distended as to burst. But when the Stomach is distended with food it presses on the Gall bladder; and thus the Bile is forced into the Intestine in a larger quantity than usual.

So that this bladder is performing two offices. Some doubt if the Gall bladder is filled in this way, and say that the Bile passes from the Liver by ducts into the bladder at once. This opinion is derived from the bladder of an ox, which is found to have Hepatic cystic ducts, but if it is so in that animal it is not a general law.

In the Serpent the Gall bladder is so separated from the Liver, full two inches, and the Bile is evidently carried by a duct from the Liver. The same takes place in some birds whose Gall bladder is loosely connected with the Liver. But in the Human subject it is certain, that the Bile passes into the Gall bladder by regurgitation only, for if the cystic duct be tied, and then water be injected

into the Hepatic none will be found to pass into the bladder, which it ought to do, if there was some other conveyance. The use of the Gall bladder seems to be that of receiving Bile when there is an obstruction in the duct, and thus it is often the means of preventing a temporary Jaundice. Sometimes there has been known an obstruction in the cystic duct when the ductus commun: Chole-
dochus and Hepatic have become enlarged to four times their natural size. The Horse having no Gall bladder, has these ducts very large. If Bile meets with a temporary obstruction only, it produces no inconvenience, but if this continues, and the Bile is not carried into the Intestine, it then produces Jaundice.

The causes of obstruction to the flow of Bile into the Duodenum, are various. A Gall stone may be the cause when situated at the termination of the ductus commun: Choledochus. Any irritation also of the fibres of the Duodenum itself may cause temporary Jaundice from the obstruction to the flow of the Bile. There are no proofs that the ducts themselves are Muscular either from an examination with the Eye, or by stimulating them, & hence Jaundice is not often arising as has been said from Spasm, but generally from the presence of a stone. A stricture has sometimes been found in the ducts, but not arising from their Muscularity.

Many opinions have been formed relative to the manner in which Bile gets into the mass of blood. Baron Haller says that the Hepatic Veins and Biliary ducts having a ready

communication, the Bile when it is obstructed in its usual channel, may by regurgitation get into the general system; and you may inject the Hepatic Veins from the Duct. Dr. Munro probably from having thought much on the economy of the Absorbents, took up the idea that Bile was carried into the system by Absorption.

He opened the abdomen of a Dog, and made a ligature on the Ductus Choledochus, and cystic Duct, and he soon after found the Absorbent Vessels distended with Bile, which was carried into the system. Tied the Hepatic duct of a Dog, and two hours after I strangled him, when I found the Absorbent Vessels filled with Bile, though there was no marks of its having passed into the general system. But some Bile may be in the system without producing Jaundice. Probably two ounces may not in the human Subject. But the experiment of tying a ligature on the duct does not disprove the opinion of Baron Haller with respect to regurgitation. I tied the Biliary duct of a Dog and in two hours after took the serum of the blood from the Hepatic Vein which produced a yellowness, when that from the Jugular of the same animal did not. We are therefore to suppose that Jaundice is produced both by the regurgitation & absorption of Bile. Of the use of the Bile we have before had occasion to speak, that it gives colour to the feces, acts as a stimulus to the peristaltic motion of the Intestines, and is the natural cathartic, & that when it is not present we have white feces, costiveness and

generally either Jaundice or Dropsy. — — — — —

LECTURE 31st Of Menstruation.

If we examine the structure and Economy of the Fetus & Adult, we find that there are very different actions set up in each.

A Fetus has the organs formed for perpetuating the Race, but their actions are not yet developed. Those organs which are vital and are immediately necessary for life, are found to be perfect in the Fetus, as the organs which carry on Respiration, Circulation, Glands &c, but those destined to perpetuate the species are not. This is a wise provision in nature, in consequence of which women have not children before they are capable of taking care of them. Some parts however which are not seen at birth, appear soon after, as the Teeth, which are necessary to perform the office of Mastication, begin to come forward about the fifth or sixth month, and the parts last formed are the organs of Generation. About the Age of fourteen or fifteen in this country changes begin to take place which we call the period of Puberty.

The softness and rotundity diminish, and give way to firmness and compactness. At that Age the body forms, & assumes Characters which mark the sex. The increase of growth at this

time is great, and the mind as well as the body is affected by indulging on the contemplation of the other sex. In man there is a protrusion of the beard, and a great change of the voice, which at first is harsh and rough, but gradually softens into a deeper and mellow tone. The Testes which were originally situated in the cavity of the abdomen, now begin to perform their secreting office. An Eunuch who may be said to live in perpetual infancy has none of these changes taking place. He has the bulk but not the figure of a man, his limbs are more rounded, like those of a woman, and he seldom stands upright, there being a flexion in his joints, which argues a defect of energy.

In other animals the same cause produces the same effect. A colt if castrated never possesses the figure or properties of a stallion, he has not the full arched neck, the sonorous voice, nor the piercing eye of that noble animal, but becomes more like a mare in his appearance. In like manner the ox does not possess the figure or qualities of the Bull. - - - -

The changes at the age of Puberty are so remarkable that many explanations have been offered for them, but they are vague and unsatisfactory and the one most presumed upon, in my opinion is fallacious. This is that at Puberty Semen is secreted and being absorbed into the system, is capable of producing those appearances which characterize this period. But if absorption was necessary to produce those changes, we ought to expect a continuance

of the cause to be necessary to keep up the effect & castration if performed at a late period of life, might throw the system back into the state it was before puberty, and this is not found to be the case; no change takes place in man or other animals castrated after this period, if we except the power before possessed of propagating their Species. The changes also which take place in Females at this period are not less remarkable, than those in man, and here the cause of absorption cannot be existing. Perhaps it would be more Physiological to say that it is a law of the Animal economy, and that these changes take place in consequence. Females we have said have changes not less remarkable than those in men. They commence rather earlier than in the male, a year perhaps in general.

The figure of the body is much improved in gracefulness and elegance, and the breasts which may be considered as appendages to the organs of generation are evolved. The constitution sometimes reaps great advantages in consequence. Epilepsy and Scrophula which have before existed now begin to disappear.

But the most remarkable change that takes place is that of menstruation, so called from the time of its recurrence, but from analogy it has been called the flowers, from their proceeding fruit, as the Menses proceed impregnation. Sometimes the discharge is called Catamenia from the same cause, of its periodical occurrence. This regularity is peculiar to the human Female; no animal besides has regular

discharges, but most as Bitches, and Beers have discharges of blood at their particular seasons of procreation. The evacuation depends then on an accumulation of blood, which renders the animal in a fit state to perform the office destined it by nature. The general age of menstruation, is about fourteen or fifteen but there are exceptions to this. Some although in good health do not menstruate until sixteen and some again earlier as twelve. I knew an instance where a child menstruated at five years old, but no change had taken place in the figure of the body, and it was therefore to be considered as a morbid rather than a natural discharge.

The period of menstruation also varies with climate, the warmer this is the sooner the discharge takes place. In the Indies they generally menstruate as early as ten or twelve, but in Lapland & the cold climates the period is much later, and the discharge is very sparing at any time. There are many causes which may accelerate menstruation, amongst these are warmth and the manner of living. Females who live poor and labour hard menstruate later than those who live luxuriously. The periods of menstruation are not always monthly. Sometimes I have known them come on at three weeks and in other instances as late as five or more.

Likewise the duration of the discharge itself varies, but in general it continues about two or three days. Sometimes there will be a kind of slight shew, and then an intermission or rather remission, and it will afterwards return and continue a week. With respect

to form any average estimate of quantities is difficult, as some calculate largely and others sparingly. Most women in health lose six ounces, many only four, and therefore between these may be estimated the common quantity. When the period of menstruation begins, the discharge is not the same it is afterwards. It contains no red particles but is limpid, watery, and yellowish, giving the linen a yellowish tinge. In a few hours however it changes and becomes red like blood. At its cessation also the red particles are withheld, and the serous part only remains. It would seem as if the vessels were not first dilated sufficiently to admit the red particles, though this takes place afterwards. Some have thought that the menstrual discharge should be considered only as a secretion, & this from its not possessing the true properties of blood. Blood consists of red particles, the coagulable and serous part, but this discharge having no coagulum is not like blood. This is evident in those cases where the menses has been retained by an imperforated hymen, and when though kept for months or even years, they have still been found to preserve their fluidity. But although natural menstruation seems destitute of this lymph yet where there is a menorrhage or excess, some lymph is common, hence in profuse menstruation, women say that it comes away in clots, and therefore the vessels must now be pervious to the coagulable part.

Perhaps the distinction between menorrhage, and natural menstruation might be founded on the presence or absence of the

coagulable lymph. Sometimes women have a shew of men-
 "ses after conception has taken place, & this for a considerable time,
 which is often considered as a forerunner of miscarriage;
 but if this does not coagulate, and more especially, if it oc-
 "curs at the expected period of menstruation it may be deemed
 of little consequence. But on the contrary if it should coa-
 "gulate and its discharge be attended with pain, it then is often
 followed by abortion. Before menstruation comes on it is
 preceded by characteristic symptoms. The female has pains
 about the breasts, shooting pains through the loins, heaviness,
 head ache and Vertigo: all which indicate the approach.

But as soon as the discharge appears, or in other words when
 the vessels are emptying themselves the woman is relieved.

Sometimes these symptoms come on, and no discharge
 follows, and again recurring at particular times causing
 distension, full pulse &c. This indicates that the secretion
 has taken place but is not discharged from an imperfect Hymen,
 or rather called imperforated. Here the simple operation of
 a conical incision will relieve, and the symptoms will ap-
 "pear. Sometimes it happens that in young females about the
 age of fifteen, or eighteen in whom no menstruation has ta-
 "ken place, a peculiar change seems to be affected in the con-
 "stitution. There is a great paleness, heat, a quick & rather hard
 pulse, with all the other symptoms which characterize Chlorosis.

These manifest a want of Menstruation, but a want of Menstruation is also sometimes indicated by accumulation, distension, and a full pulse &c. We should therefore carefully distinguish between these two causes of Amenorrhoea. In the latter of Amenorrhoea, the Animal Functions as digestion, Chylefaction, &c, generally go on very well, and the complaint arising from cold or some accidental circumstance at the period of Menstruation.

In this case of accidental obstruction V. S. Emenagogues &c, will be proper. In Chlorosis some have endeavoured to bring forward Menstruation as if that would cure the disease, but the best practitioners consider this rather as the effect than the cause of the disease. Electricity by being passed through the parts would cure the complaint, but it is found necessary in these cases to strengthen the system with Bark and Steel. Perhaps withholding the blood is wise in nature, when the constitution is not able to spare it. Therefore we should first strengthen the constitution and then act on the Uterine System. Electricity, &c, &c, may be proper now when before they were injurious. When first Menstruation takes place, it is not expected to return regularly every month, an interval sometimes of many months will elapse without affecting the health, but the greater the length of time the worse. It is sometimes a year or two before the discharge is regular, and the quantity increases with the age of the Patient. When once established it is regular and periodical. The quantity at first is less

by half than it is afterwards. The other species of Amenorrhoea is very different from this arising from Chlorosis, it is connected with strong tense fibres and a plethoric habit. A Female at the period of Menstruation may be exposed to causes which operate in suppressing the discharge. Sudden passion or emotions of the mind may have this effect, or cold by causing a constriction or spasm on the extremity of the vessels may act in a similar way. Here instead of giving Myrrh &c we are to relieve the Plethora by V. S. the Pluvian, Semi. Cuprum or Aloetic pills may cause a discharge, and the symptom will then give way. Electricity may be more proper here, for in this case we want the discharge only, while in the other there were other circumstances to be attended to.

The privation of Menstruation we have hitherto been considering as a cause of disease or at least as a symptom of it, but there are periods at which the privation is natural as those of pregnancy and Lactation. After marriage the suppression of the Menses is generally considered as a proof of conception and women generally reckon from that time. Where there is a copious Lactation unless there is a great Plethora, no Menstruation takes place, and it is always considered as an objection to a nurse if she menstruates. Some have supposed that suckling precluded the possibility of Impregnation, and under this Idea many Women have continued to suckle their children. This may in some degree be true, yet women who while suckling

have enjoyed the pleasures of Impregnation, and have often found themselves deceived in this particular. The Ancients thought that this discharge was noxious and that Menstruation was purging the system of its impurities, but women have no more impurities than Men, and consequently do not require an outlet for their removal. This discharge differs from blood, but whether it is a secretion or not, I will not now decide.

It differs from blood by not possessing the coagulable Lymph. It may be well imitated by stirring blood reduced into a basin with a stick, when the Lymph will coagulate round it, & leave the Serum & red particles only in a state of mixture. When we consider the Uterus as possessing numerous Vessels, and having more blood sent to it than is necessary for its nourishment, and also that these Vessels terminate on its interior surface by open mouths, it would lead us to suppose that this organ itself was the seat of its secretion. The Arteries going to the Uterus are the two Hypogastric, and the two Pneumatic. An injection will pass by these into the Uterus itself. The Lochia which are known to come from the Uterus after delivery very much resemble the Menstrual discharge. In Women also who have died about the period of Menstruation this part has been found very vascular. Likewise in cases of Prolapsus Uteri which happen about the period of Menstruation blood may be squeezed out of the Vessels of this organ, and where the Uterus has been

inverted during labour it has given an opportunity to see the blood flow from the vessels on the internal surface of the Uterus. Ruysch relates a case of this kind where he saw the blood flow immediately from them. But some have considered the vagina as furnishing a part of the discharge and Pinneus records two cases which carry with them some speciousness in support of this opinion, yet they do not prove the fact and may be explained in a more consistent manner. It has been a question much disputed, whether this discharge issues from the Arteries or the Veins of the Uterus.

One argument for the latter opinion has been the colour of the discharge, but this has no weight, for in the capillary vessels the Arterial Blood differs very little from the Venous. The late Mr. Hunter and another gentleman in making an experiment to ascertain whether there existed any other communication between the ovaria and the Uterus than by the Fallopian Tubes, were inclined to favour this opinion. After having tied the Fallopian tubes they threw some injection into the Uterus by its mouth, & found that some of it had got into the veins of that organ.

This they conceived proved that the discharge came from the veins, but this is not generally allowed. The Veins also have been said to be more favourable to accumulation than the Arteries, & as the discharge is depending on that, it was said to be probable on that account. But Venous Plethora takes place late in

life, while evacuations of all kinds in early life arise from Arteries, and therefore it is probable that this discharge comes from Arteries than Veins. Little steps as we have before said is to be laid on colour, for the similarity between Arterial blood from the capillaries & the Venous, and we know that the Catamenia flows only from capillaries.

When the natural passage to the menses is obstructed it comes sometimes by the lungs or nose, and if there is an Ulcer on the Leg it has been known to be discharged from these parts, and to have disappeared when the passage has been restored. Some have referred the cause of menstruation to the moon, but if this influence existed all women ought to menstruate at the same time, which they do not. There are two other opinions on this subject those of general and local Plethora. Those who favour the former opinion speak of the preternatural outlets which we before noticed, and say that nature relieves herself by other means when the natural are obstructed. This appears at first probable, but Plethoric women are found to menstruate sparingly, and relaxed constitutions often abundantly; and women who loose blood at the period of menstruation do not find secretion diminished, whereas the losing of four or six ounces of blood ought to prevent it entirely.

Hence this discharge is not depending on, nor does it relieve general Plethora. It is more probable depending on a local determination of blood to the Uterus, but what is the cause of this is difficult to say. the state of the Mind perhaps determines it

occasionally. I heard a remarkable case of this kind. A Lady whose Husband had been abroad sent her intelligence that he should return at a particular time. Now this was not the time she expected her Menses, but an association of Ideas of a particular kind, more easily conceived than described, agitating her mind, produced the discharge. The final intentions seem to be of Keeping the Uterine system fit for conception, the Vessels of which are in consequence more pervious. The connection between the Uterus and Ovarium is better kept up, and the Vessels are in a better state for insensating with the maternal part of the Placenta. The well known fact of Impregnation taking place not till after Menstruation has commenced most certainly favours this opinion. —

LECTURE 32^d Of the Male Organs as concerned in Generation.

Having finished what related to the Economy of the different organs most essential to life we come now to consider the means and resources which nature has provided for perpetuating the Species. In doing this we shall not enter into the investigation as to the different manner in which this is performed by different Animals, but we shall confine

ourselves to what immediately concerns the human species.

In Man and other Animals the race is propagated by mutual intercourse. We shall therefore first consider the seminal fluid by which conception is produced. Secondly, the other fluids which usually mix with it. And lastly, the conveyance of this fluid into the uterine system of the Female. The Testes are the organs secreting this fluid. They are two in number, and situated before birth in the cavity of the Abdomen. About the time of birth or soon after, they descend into the Scrotum. In some Animals as the Hedge Hog, and in all Birds they remain in the Abdomen during life.

The Testes of Birds undergo great changes at different seasons. In the Summer during the time of procreation they are large, but in the Winter they shrink to a very small size. In Horses the Testes remain sometimes in the cavity of the Abdomen during life, and such by the Farmers are called Rigs. We must consider the Testes in the same order as other glands, first taking a view of the Vessels which supply them with blood, and next of their interior or secreting structure. The Vessels which carry the blood to the Testes are the Spermatic which arise from the Aorta near the Emulgent Arteries. It would seem an objection to the general law of nature that they should arise at such a great distance from the part they are meant to supply, but this is applicable to the Adult only and not to the Fetal state. The Spermatic Arteries pass through the Abdominal Ring dividing into two branches, one of which is going to the Tunica

Vaginalis Testis and other coat; and one to the Testis itself.

Previous to their entering the Testis they make several convolutions and this is more particularly the case in Horses, which renders the length of the canal greater, and as the greater the distance from the Heart the slower must be the circulation; it seems that nature intended by this that the fluids should be more elaborated, and better fitted for forming an offspring which in time is to produce a similar secretion. The circulation through the Artery is made slow from its structure which is like that of a vein. In the Testes as in other Glands a considerable portion of blood must be returned, hence there must be Veins, and the Arteries must have communication with them.

These Veins when we consider their size and number bear a great proportion to the size of the Artery. In general there are five or six and each nearly as large as the Artery which renders the circulation still slower and more languid. This is further favoured by its position, the blood having to mount contrary to its gravity. These Veins freely Anastomose and on the right side they return the blood into the Vena Cava, & on the left, into the left Emulgent Vein. But as the ultimate branches of the Spermatie Artery must have another termination besides that of Veins, we must enquire what that mechanism is. We are Anatomically informed that the Testes are tubular. They appear at first sight as a mere pulpy mass, but by maceration they may

be unravelled, and you may pick out a series of convoluted vessels or tubes, which somewhat resemble a rumpled skein of fine thread.

Now injection proves them to be hollow tubes, but to fill them we must not inject in the course of circulation, but the contrary way.

Hence they must be injected by the excretory duct of the Testes, and not by the Spermatic Artery. Anatomists and Physiologists have exercised their ingenuity to discover the length, size and number of these tubes. Some have said if drawn out that they would measure several leagues, others only a mile; but Dr. Mums, has formed calculations from which he says that there are about three hundred tubes, each of which is about ten feet in length, so that taken collectively they would measure three thousand feet or three quarters of a mile. He has also endeavoured to ascertain their diameter by the use of the micrometer, and this he finds to be about the two hundredth part of an inch. But though this calculation may apply to the human species it will not to other Animals. Some Animals secrete Semen very fast, and hence are able to copulate frequently. In the Rat the Tubuli Seminiferi are four times as large as those in the Human subject. It seems probable to me that in these tubes or in the branches of the Arteries terminating in them, that the secretion is at first imperfect containing a watery part and hence we find numerous vessels to absorb and return the superfluous quantity into the general mass of fluid. The secretion is probably performed chiefly in the termination

of the Artery, as the tubes seem to contain only Semen, but this change affected by the Arteries must be taking place after the return of part of the blood by the Veins. These Absorbents are numerous and that they carry the watery part and not the Semen is evident from their transparency, the latter being opaque. They may be readily injected. In every gland of the body there appears to be a communication between it and the Mind. This is evident in the Kidney but in the Testes it is greater than in any other gland, hence we suppose that there are many nerves going to the Testes and distributed to the Testis itself. These nerves have a somewhat peculiar sensation given when injured a dull obtuse pain which is often followed by sickness. In other parts under similar circumstances the pain is more acute. That it is in consequence of these nerves, that the secretions are carried on is evident from what we find to take place. When a Man is in company with a Female, under the influence of certain ideas, if he were to examine minutely he would find some degree of tumor not in the Testicle itself, but in the Epididymis. This probably is depending on an accumulation of secretion from the Semen passing from the Testes and not being discharged, a painful distension is the consequence. This furnishes a sufficient proof of the influence of the Mind over the Seminal secretion.

When the Seminal secretion has been performed by the Tibuli and the Arteries, there must be some way for it being

conveyed from the Testis and accordingly we find there are a set of vessels called *Vasa efferentia* from their office of carrying away a fluid. These *Vasa efferentia* are about ten or twelve in number and partly from the Epididymis one third being performed by them, and two thirds by the Membrane investing them.

The Epididymis can by injection be clearly proved to be one canal only, but much coiled and convoluted. The Semen then is conveyed from the Testis to the Rete, from them to the *Vasa efferentia*, thence to the Epididymis, and from there to the *Vas deferens* which is formed from the latter. Many opinions have been formed relative to the nature of the excretory duct, the *Vas deferens* and the manner in which the Semen is conveyed through it. Now the vessel when recently examined appears like a thick string chord, but when cut into, it is found to be hollow although small in its diameter. But what is the nature of the substance forming it? Those who reason from necessity say that there are longitudinal and circular orders of fibres. Now we know that a Peristaltic motion would take place where this structure exists as is the case in the Intestines. Launcebrook says he saw these fibres. I also attempted to discover them by the help of glasses, but never yet succeeded, although I think it probable they may exist, and that the motion of the Semen may be accelerated by them, as it must pass in opposition to its gravity.

There is something peculiar in the termination of this canal

which deserves attention. Just before the Vas deferens terminates at the posterior and inferior part of the bladder it enlarges and forms a swell. On examination we find this to be caused by its terminating in a number of cells, so that there is an enlargement of capacity as well as of substance. There are also two cellular bodies called the Vesiculae Seminales, and the Vas deferens on each side uniting with one of them, they run in a parallel direction, and terminate ultimately in the prostate by one common duct.

The general opinion is that the Vesiculae Seminales are the receptacles for the Semen. This seems probable for if you inject the Vas deferens, you fill the corresponding Vesicula Seminalis.

Now as the Semen takes the same course why may it not regurgitate here. That it passes from the Testicles into these Vesiculae which form a reservoir, and also why may not the Testes have a receptacle for its secretion as well as the Kidney.

But there has been an opposition made to this opinion & there are some striking parts against it. Mr. Hunter seems to have been the first who opposed this opinion. He says if you examine the fluid contained in the Vas deferens, you will find it different from that in the Vesiculae. Now the fluid in the Vesiculae is brown, but that of the Testes is white, which ought not to be the case if they were the same fluid. I believe there is some truth in this opinion, for on examining the Semen of a Horse, I found the difference of colour to exist, and even on injecting a fluid

into the Vas deferens it passed into the bladder just below the Prostate instead of regurgitating into the Vesiculae. Hence in that Animal at least the Vesiculae are not receptacles for the Semen.

Mr. Hunter has likewise examined the Vesiculae in those who have been semicastrated, and found them uniformly to contain a fluid on that side as well as on the sound side. In one instance he examined a married man, who had been thus castrated, & who had afterwards cohabited with his wife, and notwithstanding he had frequently made use of these parts, the Vesiculae were as full on the castrated side as the other. Hence he was led to suppose that they were secreting organs capable of distending the cells without any interference from the Testicles. I think this very probable from what I have myself seen: in a subject brought into the dissecting room who had undergone the operation for Dythotomy, I found the duct of the Testis on the left side obliterated just before its usual termination in the Vesiculae Terminalis, and yet this contained the fluid. I afterwards met with another instance more strong than this. If then these Vesiculae are not reservoirs, are there any parts serving this purpose? Now we before noticed a swell which occasionally existed in the Epididymis, and Mr. Cline conceives this to be the Receptaculum Seminis, which I think is very probable. But the mind having so much controul over these organs it is secreted occasionally and therefore only a small receptacle is required. But then what is the use of the

Secretion of the Vesicula? It is highly probable that this with two other fluids which we shall have occasion to mention, mix with the Semen in its passage and serves as a vehicle by which it is more easily conveyed into the uterine system of the Female.

M^r. Hunter questioned this opinion of its use. He examined these parts in a Guinea pig and found them thick, He could not discover any appearance of it in the Vagina of the Female after Coition. But if they are not for this purpose, we know not of what use they are for. Besides the organs we have clearly spoken of, there are two small bodies called Cowpers glands (which are often wanting) and the prostate gland. The former are situated at the bulb of the Penis and have excretory ducts terminating in the Urethra. The Prostate is very vascular and composed of many follicles from which go excretory ducts. It is situated at the neck of the bladder, and the excretory duct of the Testes after joining with the m^utanum. It is probable that the fluids of these glands & that of the Vesicula mix with the Semen in its discharge at the bulb of the Penis. But a certain condition of the male organs is necessary for the performance of the generative act, that is, the Penis must be in a state of erection, as nothing is to be done with a flaccid Penis. The erection is evidently depending on the presence of blood. This Dr. Groom proved by making a ligature on the Penis during its erection, and then puncturing it and letting out the blood, and the erection immediately subsided. But how is that blood accumulated there?

To understand this it is necessary to consider the structure of the Penis. The Penis is composed of the Corpora Caverosa which are of a spongy structure, so that if we distend the Penis with Spirit, and harden it, and afterwards cut it through, we find it to be very cellular. The Corpus Spongiosum & Glands Penis seem to be similar in structure, but instead of cells they are found to be made up of a number of convoluted vessels or rather Veins which have communication with Arteries. Now in what manner is the blood conveyed. The Arteries supplying the blood are the internal pudendal which at the pubes divide into four branches, two at the upper part going to the corpora Caverosa, & two at the bulb entering the Corpus Spongiosum. There is always blood circulating through this organ but there is not always an erection. What is the cause of this? It is first necessary to know the circulation through the Penis. If we inject the Penis we find that the Veins have their origin from the cells of the Corpora Caverosa, hence it is evident that the Arteries pour blood into the cells of the corpora Caverosa, and that the Veins return it into the Vena Magna so that the last vessel is the only one conveying blood from the penis. Now how does this agree with the economy of the circulation in other parts? Why is the balance here contrary to the general rule in favour of the Arterial circulation? It has been generally supposed that compression on the Vena Magna by the arch of the Pubes preventing the return of blood produced

the erection. Pressure may in some degree be made, but it cannot until the erection has taken place, it is therefore rather the effect than the cause of erection. To obviate this difficulty some have said that the vein is muscular, irritable, and that when erection takes place spasmodic affections of the vein prevent the return of blood. But I tried the effect of this by stimulating the Vena Magna of a dog, but it gave no proof of irritability. I think however it may be explained. We have spoken of the influence of the mind hurrying the secretion and granting this, the empire of the mind may be as great over the Arteries going to the Penis, as over those which enter the Testes. In common the small Vena Magna may be sufficient to return the blood but during erection it is not, and therefore as long as the mind operates the erection will continue. The balance before mentioned in favour of the Arterial circulation renders this more probable and the determination of blood to the Penis may be farther assisted by the action of the Erectores Penis, and Ejaculatores Seminis durante coitu some changes take place, the Semen passes from the Testis and mixes with the fluids from the Prostate &c.

In the bulbous part of the Urethra, this producing distention, stimulates the Ejaculatores Seminis and Levatores Ani which causes a spasm on these parts and a consequent ejaculation of the Semen.

Finis

Andover }
March 11th 1815 }

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